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EXTRATERRESTRIAL

ENCOUNTER

A STARTLING SURVEY OF ALIEN INTELLIGENCES AND MANKIND

Foreword by Professor A.E. Roy

THE SEARCH FOR INTELLIGENT LIFE IN THE UNIVERSE

WHO GOES THERE?

EDWARD EDELSON

WHO GOES THERE?

WHO GOES THERE?

The Search for Intelligent Life in the Universe

Edward Edelson

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CONTENTS

List of Illustrations vii

Introduction ix

Chapter One Viking to Mars 1

The Landing The Pictures The Tests Where Have All the Organics Gone? No Life on Mars? 1984: Back to Mars?

Chapter Two Where We Come From 17

Beginnings A Universe Too Vast to Comprehend Galileo's Intellectual Giant Step The Moon Hoax The Romance of Mars Measuring the Universe The Great Galaxy Debate

Chapter Three Chemistry and Life 31

From 'Vital Force' to 'Warm Little Pond' The Mechanisms of Life Fingerprints in Space The Seeds of Life

Chapter Four The Universe and Us 44

Telescopy 'Big Bang' vs 'Steady State' Stars Are Not Created Equal Barnard's Star

Chapter Five Once Around the Sun 57

Hell on Venus Life on Earth Mars: The Untold Story Life on Jupiter: Hard to Imagine Titan: a Possibility

Chapter Six The Formula 67

$N=R_*f_pn_ef_lf_if_cL$ Factors in the Equation L=The Major Question Facing Mankind Where Are They?

Chapter Seven Who Goes There? 75

They're Already Here Welcome to Ufology The First 'Projects': Saucer, Sign, Grudge, Blue Book The Condon Report Wilder Music: The UFO Craze Case Histories The Chariots of von Däniken The Response of Astronomy Close Encounters of a Questionable Kind

Chapter Eight Travelling 88

Interstellar Voyages: A Question of Propulsion Space Ark: An Ecological Community Enzmann's 'Flying Iceberg' Of Lasers, 'Ramjets', and 'Hyperspace' Is Interstellar Flight 'Out of the Question'? Sending Unmanned Probes to a 'Likely Star' An Interstellar SOS? Travellers vs Listeners Listeners vs Travellers The High Cost of Travel

Chapter Nine Listening 103

'Our Only Hope at the Present Time' The Main Street of Space The 'Water Hole' of Space Signals to Expect SETI: From *Enfant Terrible* to Middle Age Project Ozma False Alarms Galactic Sweeps

Chapter Ten Messages 121

Sending Mathematical Pictures Drake's Message: 'An Anti-Puzzle' Message to Jupiter Phonograph Records in Space Launching Bottles into the Cosmic Ocean The Fear of Contact

Chapter Eleven Strategies 134

Project Cyclops Lunar and Orbiting Systems The Business of NASA SETI Grows Up SETI: Soviet Style

Chapter Twelve Futures 150

The Doubts The Hopes The Faith of SETI A Vision of the Future Space Colony The Choice: Space or Stagnation The Poetry of SETI The First Chapter in a Long Story

Index 169

LIST OF ILLUSTRATIONS

FIGURE 1: A schematic drawing of the Viking pyrolytic-release experiment. (NASA)

FIGURE 2: The message sent by the Arecibo radio telescope on 16 November 1974. (Cornell University)

FIGURE 3: The plaque carried into space by the Pioneer 10 and 11 spacecraft. (TRW, Inc)

FIGURE 4: A proposed surface rover for a future Mars mission. (JPL)

FIGURE 5: Cyclops as seen from the air. (Ames)

FIGURE 6: An artist's concept of a relatively small SETI system in space. (Ames)

FIGURE 7: Part of the orchard of antennas of Project Cyclops, as seen from the ground. (Ames)

FIGURE 8: A Bernal sphere that could house 10,000 people in a space colony. (Ames)

FIGURE 9: The interior of a proposed space colony. (Ames)

INTRODUCTION

There are some scientists who have a breathtakingly optimistic vision of the human race in the twenty-first century.

On the earth, science and technology have met the major challenges facing humanity. Famine has been held off; over-population has been checked; energy supplies are ample. Terrestrial affairs are run with the help of computers whose power is greater than that of the human brain. Humanity is extending its powers by symbiosis with machines and computers. Because of science and technology, the human race has achieved a level of well-being never before possible.

With its home base secure, humanity is advancing into space. There is a small but growing colony on the moon, where the techniques of lunar mining have been mastered. Several thousand people live in a self-contained space colony, and lunar ores are being processed to build more space islands. Mars has been thoroughly explored by unmanned rovers, and the first manned Martian colony is being planned. Scientific teams are working on long-term programmes to transform Mars from a bleak and inhospitable desert to a planet that is suitable for human habitation.

Almost – but not quite – forgotten in this period of busy extraterrestrial growth is a decades-old project in which teams of scientists from every nation on earth are methodically searching for signals from other civilisations in the universe. It is a programme that is being carried on both on earth and in outer space, using the earth's best minds and its most complex technology. Advanced computers working at the biggest astronomical facilities ever built are automatically scanning millions of radio-frequency channels from star after star. Hundreds of thousands of stars have been scanned over the decades. Aside from a faint twitch now and then, the results have been entirely negative.

Then, one day, the computers detect signs of organisation in one of the channels they are scanning. The vision is that of Frank Drake, an astronomer at Cornell University who is one of the leading figures in the search for extraterrestrial life:

> . . . a signal is received from a direction fixed among the stars. Its frequency never changes. Thus, it must be of artificial

origin. Its creator has corrected for the Doppler shift at the orbital motion of the object from which the signal comes. Only now is it noticed that every ten minutes the phase of the electrical vector which describes the signal is precisely inverted.

This is absolutely conclusive evidence of the intelligent origin of the signal. The signal is carrying a message in binary code, a message that will be received for a year before the scientists understand the format of the message and recognise it as the song of people who have been alive, every one of them, for a billion years. They are sending the information which will make this same immortality possible for all the creatures of earth.

As never before, the people of earth now hold their destiny in their own hands . . .

That is the dream of the scientists who have created the field that is sometimes called exobiology and sometimes called SETI – the search for extraterrestrial intelligence. It is a vision of the human race enriched and even transformed by the wise use of technology and by contact with older and even wiser civilisations.

SETI is a young concept, but it is old enough to be suffering through its first crisis. The crisis is due to the close relationship between SETI and big, complex technology.

The idea of communication with civilisations elsewhere in the universe came of age in the 1950s and 1960s, a time when big technology was in its fullest flower. There seemed to be no limit to the growth of technology, especially space technology. Project Apollo had placed men on the moon. An ambitious programme for reconnaissance of the solar system had been conceived and was to be largely carried out in not much more than a decade. Even more ambitious space programmes were proposed.

Scientists in the field got used to thinking big, in billions of dollars and hundreds of millions of miles – not out of bravado, but because the vastness of the solar system and of the universe demands it. And, inevitably, the scientists who are working to make contact with other civilisations think big because their subject demands big technology.

The elementary calculations in SETI indicate that to make contact with another advanced civilisation, we must either be very lucky or else use big machines for a long period of time. Modern technology may seem impressive. But if we compare the search for extraterrestrial civilisations to a poker game, the human

race now has roughly the equivalent of one blue chip – a technology that barely gives us the ability to get into the game. Maybe we will be lucky enough to win the pot with our first ante. But the odds appear to be against us. The assumption in SETI is that we must start with today's technology and move tenfold, a hundredfold, a thousandfold.

That sort of technological extrapolation was unchallenged in the 1960s, when all the arrows pointed up. But the 1970s have seen the rise of a different spirit. The 1960s were the decade of growth and expansion, of 'bigger is better' and 'the sky's the limit'. The ideas that seem to have captured the public imagination in the 1970s are 'small is beautiful' and 'the limits to growth'. A decade ago, only the benefits of big technology got consideration. Today, for an influential minority, at least, only the dangers of big technology seem evident, and there is a feeling that rather than exploring the universe, humanity would be better off tending its walled-in garden.

The scientists in SETI are keeping the technological faith, but they are very much aware that the issue is in doubt. In the complex formula by which the scientists attempt to estimate the number of advanced civilisations in our galaxy, perhaps the dominant factor is the lifetime of a technological society. One possibility is that a society such as ours will neither wipe itself out with nuclear weapons nor poison itself with pollutants, but will simply turn its back on technology.

Some scientists and philosophers of science say that European civilisation, which first came to dominate the earth and then pushed into space, is unusual in the relatively brief history of human civilisations. We assume that the urge to explore and conquer is a basic attribute of human beings, but this may not be so. The Western idea of progress, which implies continued growth and expansion, and a continually increasing control over nature, is not the standard pattern on earth. Most civilisations have thought in terms of living in balance with nature, not of conquering it. Instead of a future of open-ended expansion, they have thought of recurring cycles, motion without progress. Instead of putting their hopes in the future and in progress, other civilisations have tended to look backwards to a golden era of the past.

In the West, the idea of stasis is gaining ground. But the issue is by no means decided. Ten years from now, we may see the first years of space exploration as the promising but crude forerunner of true conquest of the universe. Or we may look back on

our space adventure as an entertaining but essentially extraneous episode in humanity's earthbound future. The matter is being decided right now; not in any sweeping, grand debate, but in the more prosaic arena of budget hearings. Engineers, scientists, and other believers in SETI talk mostly to each other. So do the anti-technologists. Meanwhile, Congress (and its Soviet counterpart) wrestles with this great subject in terms of money. Do we spend the half-billion dollars or more needed to send rovers to Mars in the 1980s? Do we allow an appropriation for studying the feasibility of a multi-billion-dollar radio-telescope facility devoted to SETI? Will we spend the money for rockets that could let us build space colonies? Do we appropriate a few million dollars so that radio telescopes can begin a search for extraterrestrial signals?

It may seem absurd to reduce something as meaningful as SETI to haggling over money, but the method makes sense. By and large, Congress will do what we Americans want it to do. If our faith in space exploration and its technology is alive, we will continue to push out into the solar system and beyond. If we turn thumbs down on technology, space exploration and the search for extraterrestrial intelligence will either limp along marginally or will fade away. If we give up, we save fairly large sums of money but lose the chance of being inducted into a galactic civilisation whose capabilities could be beyond human understanding. Admittedly, it is a relatively slim chance, but those in SETI believe that it is worth the effort, even at great cost. Opposing that view is the thought that humanity should first see to its own basic needs, using the simplest possible technology, rather than building expensive space cathedrals while people starve.

The debate could be settled in a simple, catastrophic way. The big-technology option could be foreclosed because the earth suffers a global breakdown in any one of the many ways that pessimists can describe in vivid detail. We could starve ourselves out of existence, or upset the planetary balance and make the earth unlivable, or use all the nuclear weapons that have been perfected and distributed by political leaders. The survivors would then know with some certainty the expected lifetime of a technological civilisation on earth. The knowledge would not do them much good, but it would settle a major point of debate in SETI.

Sometime in the next few decades, we will find out whether there is intelligent life on earth. At that point, the search for life

elsewhere in the universe may begin in earnest. And here is the paradox: the fact that the search has begun here will be a good sign for its success. For we will then know that one technical society – ours – has begun an effort to contact others. That knowledge will give grounds for believing that the same decision has been made elsewhere in the universe.

For those who believe that humanity's future is tied to large-scale technology, the very existence of a search for extraterrestrial life will be a hopeful indicator for the human race. For them, the choice is between the earth and stagnation, or outer space and continued expansion. The question of spending a few million dollars for an organised continuing search for extraterrestrial signals thus becomes one of the great decisions of our time.

If we pare away the externals, the issue seems clear-cut. But the externals never are pared away. The decision about a search for signals from an extraterrestrial civilisation will be made against a kaleidoscopic backdrop of conflicting interests: public interest in the technology of space, public demands for less federal spending, a fascination with unidentified flying objects by most non-scientists, scepticism about UFOs by most scientists, trust of scientists as the bringers of progress, distrust of scientists as the creators of technological monsters. And more.

It is hard to predict what the search for extraterrestrial intelligence will look like next year or ten years from now. But it can be said that the swift rise of this new discipline to scientific respectability is one of the more interesting phenomena of our time. Because of SETI, the human race can look at itself, its star, its planet, its solar system and its galaxy in a different light. Science has changed mankind's place in the universe drastically; from a species that bestrode creation, we have become just one product of evolutionary forces on a minor planet of a mediocre star. Now science offers us the hope of moving back towards galactic importance; if not on our own, at least in co-operation with other species who share an intelligent mastery of technology. To the pioneers in the search for extraterrestrial intelligence, this prospect is the most exciting one that the human race can have. Now we must see whether those pioneers can make their vision come true.

Already we have passed one milestone: we have gone off the earth to look for life on another planet. The Viking mission of 1976 sniffed around for life on Mars. Its findings, like most other data in SETI, were indefinite, provocative, and subject to debate. But the truly important point about the Viking mission was that it

was accepted as a normal step in the exploration of space, even though the principles behind the mission would have been regarded as impractical dreams a few decades ago. Viking meant that exobiology is in the mainstream of science. The human race went a long way both physically and psychologically when life-detection instruments began operating on Mars. Viking is a good place to begin our search for life elsewhere in the universe, as well.

CHAPTER ONE

Viking to Mars

The Landing

'Touchdown! We have touchdown!'

The time was 4.53 a.m. on 20 July 1976, the place, the Jet Propulsion Laboratory in Pasadena, California. The voice on the loudspeaker belonged to Richard A. Bender, the head of a group of engineers and scientists whose job was to see that a Viking spacecraft landed safely on the surface of Mars. He was a happy man.

Everyone at JPL that night was smiling. Viking I had landed perfectly, and people were cheering and jumping. The exultation was inevitable, since about seven years' effort and a billion dollars were riding on the landing. But there was an extra measure of exultation that came from the unusual suspense that was built into the final minutes of the descent from Martian orbit to the surface of the planet.

For almost twenty minutes, the scientists and engineers around the consoles at JPL knew as little about the fate of Viking as anyone else on earth. When the descent began, Mars was more than 220 million miles from earth. Radio signals from the spacecraft to earth could travel no faster than the speed of light. There was an unavoidable twenty-minute delay as the signals made the 220-million-mile trip. If anything went wrong, JPL would not know about it for those twenty minutes.

They were the chanciest minutes of the mission. Viking was making what amounted to a blind landing on an unspecified spot in uncertain terrain. Indeed, the very fact that the landing was taking place on this date, 20 July, was a tribute to the uncertainties of Mars.

The original date was 4 July 1976, a nice, round bicentennial day selected on what could be called the why-not principle: as long as Viking I (it was the first of a pair; the second was not far behind) had to land early in July, why not Independence Day in particular? But that date created a small deadline problem in verifying the safety of the landing site.

The primary landing site was on a Martian plain called Chryse, near the equator of Mars. It was chosen from careful study of the pictures taken by Mariner 9, which had orbited Mars for nearly a year, starting in November 1971. The Chryse landing site was picked because it seemed to combine interesting terrain with a good degree of safety. The site was at the mouth of a feature called Valles Marineris, a 3000-mile-long canyon that could swallow up the Grand Canyon with ease. From the Mariner picture, the Chryse area appeared to be a drainage basin for a number of sinuous channels, which looked like dry riverbeds. If there had ever been running water on Mars – a question that was being disclosed with intensity when the two Vikings were launched in August and September 1975, and all through their 400-million-mile voyages – Chryse would be a logical place to search for its effects. Since most scientists believe that water is essential to life, Viking would look for life in a place where water might once have flowed on Mars.

But the Mariner 9 pictures were on too large a scale to pinpoint a safe landing site. Their resolution was good enough to show large features, but they could not show smaller irregularities that would be enough to ruin a Viking attempt at landing. The final landing site could be selected only after the Viking spacecraft went into orbit around Mars. On board the Viking orbiter were cameras whose resolution was much greater than those carried by Mariner 9. As Viking circled Mars, its orbit would be adjusted to bring it over the proposed landing site.

The pictures transmitted from the Viking orbiter would be only part of the material used to make a final decision on the landing site. Readings from a radar facility on earth would be studied with equal care. Just about the time that Viking went into Martian orbit, the Chryse site would come into range of the earth's largest radio telescope, at Arecibo, Puerto Rico. Working as a radar set, the 1000-foot antenna at Arecibo would be able to obtain extremely good information about the smoothness of the Chryse plain.

When the Viking orbiter pictures began to come in, they showed a scene that presented both opportunites and problems. Mostly, they showed clear evidence that water had once flowed on Mars, and in large amounts. There had been some debate about the origin of the sinuous channels in the Mariner 9 pictures. Most scientists believed that the channels were cut by running water, but some held out for lava flows or wind action. There could be no doubt about the features in the Viking

pictures, which showed much finer details than the Mariner images had provided. Water had flowed on Mars, all right. There had been a northerly flow that had cut riverbeds in the Martian soil, leaving behind eddy channels and 'islands'. In some parts of the channels, water had flowed violently enough to strip away the surface layer, creating a patch of scabland.

The existence of the channels raised a number of questions. When did the water flow, recently or long ago? Where had the water of Mars gone? Was the era of water flow on Mars a once-only event, or did the Martian climate go through cycles that would periodically bring floods to the now-dry rivers?

Those questions could be tackled later (although speculation began immediately). For the moment, the signs of water were good news. Water means life, or at least the possibility of life. One major objective of the Viking mission was to look for signs of life on Mars. Therefore, the indications that water had once flowed in the landing area meant that the search for life was off to a good start.

But the pictures also showed that the designated landing zone was not as safe as had been thought. The ancient Martian rivers had not emptied into the Chryse region; they had flowed right across it, cutting deep into its surface. The Viking scientists were looking at a region that was much more complex and much rougher than had been anticipated. The area could be studded with blocks big enough to tip the Viking lander over. If one of the lander's three legs should hit a large block, the craft could end up helpless on its back, like a turtle on earth.

Reluctantly, Viking officials gave up the 4 July landing date so that the area north of the original landing site could be reconnoitred. The Viking orbiter's cameras were pointed at the more northerly area. They showed smoother terrain and diminishing channels. The Arecibo radar signals crept across the area. They found a spot that appeared no rougher than average Martian terrain. The new site was chosen: 22.4° North and 47.5° West, by the latitude and longitude established by terrestrial scientists. (More accurately, the landing site was an elongated elliptical area centred on that point. There was a potential drift of several miles in the exact landing point.) And the new landing time was set.

Viking landed quite the way it was supposed to. The scientists could use the word 'perfect'. The lander separated from the orbiter; rockets were fired to start its descent; a protective cover was jettisoned. At the appropriate times, the lander's three legs

were extended, a parachute was deployed to slow its fall, and a radar altimeter ignited three descent engines that set the craft down on the Martian surface with nothing more than a slight bump. In retrospect, it was all routine for a landing on Mars.

But think about seven years' work and a billion dollars spent on planning, building, testing and monitoring, all coming down to one moment. The pressroom and the auditorium at JPL were jammed with people who had stayed up all night. On the television monitors you could see the men in the control rooms doing the silly things that come in the moment of jubilation. James S. Martin, Jr, the rock-solid project director of Viking, was wearing a funny T-shirt. Everyone was laughing.

A few minutes later, it was back to business. The computer on board the Viking I lander was programmed to begin taking pictures immediately after landing. One of the lander's two cameras was pointed towards a footpad of the spacecraft and the Martian soil around it. It was an unusual camera, one that did not have a lens. There was a moving part: a mirror that nodded up and down. Light from the mirror was captured by a sensor. The sensor translated the light signals into electronic signals, which were beamed back to earth. At JPL, the electronic signals were translated back into light signals. As the mirror nodded, the entire camera rotated slowly, building up an image as a collection of vertical strips.

The Pictures

You could call the camera a life-detection system. It could detect a Martian plant or an animal. The scientists had said jokingly that if anything walked by the spacecraft on Mars, its image would be sent back to earth – although it had been calculated that an elephant might escape detection if it walked just ahead of the swivelling camera. No one expected elephants, but it was hard to tell what to expect in the first picture from Mars. Indeed, although the camera system had been tested and retested exhaustively on earth, no one could be sure that it would work well on Mars, and there was uncertainty about the quality of the images that would arrive at Pasadena across 220 million miles of space.

The audience in the pressroom and the auditorium would find out as quickly as the scientists, since the picture was put on the television monitors as it came in. Thomas A. Mutch of Brown University, the leader of the lander imaging team, gave a running commentary. From the first, Mutch's straight scientific

narrative was studded with superlatives: 'incredible . . . fantastic . . . unbelievable . . .' He was talking about the quality of the pictures, which might have been taken just around the corner rather than 220 million miles away. The first picture from Mars, building slowly on the TV monitor, showed rivets in the cup-shaped footpad, Martian sand that had collected in the footpad, pebbles a fraction of an inch across, rocks half-buried in Martian sand. There had been those worries about the quality of the pictures that the lander cameras would take. As it turned out, the doubts were unnecessary. The camera system was superb.

The excellence of the system was proved in the second Viking picture, a 300° panorama of the Martian surface near the lander. This time, the content as well as the quality of the picture was reason for superlatives. In the time of testing, the camera system had been taken out into the desert of the American Southwest. The first Martian panorama showed a scene that could have been part of that desert. The scene was impressive not because it was Martian but because it was so deceptively earthlike. If you looked hard, you could pick out an abandoned Volkswagen, a crushed beer can, a dry stream bed, and even a crooked letter 'B' on the side of a rock. None of them were there, of course, but the impression of a terrestrial scene was hard to shake. Even the brightness of the sky helped create the impression. Before Viking landed, most Viking scientists assumed that the lighting on Mars would be more moonlike than earthlike, a glaring contrast of brightly lighted areas when the sun hit and deep shadows where it didn't. The earth's atmosphere carries suspended dust particles that scatter sunlight. The moon has no atmosphere, so light is not scattered. The Martian atmosphere is only a small fraction of the earth's. If we set up a unit of atmospheric density and say the earth's atmosphere rates at 1000, the atmsophere of Mars rates at about 7 – less than one per cent as dense. (There is such a unit, called the millibar.) Therefore, Mars was not expected to have a bright sky.

But it does. Apparently, there are enough suspended dust particles in the thin Martian atmosphere to soften the glare. The first colour picture, taken the next day, added an exotic touch: not only is Mars red, but its sky is pink. We can say quite accurately that Mars is rusty: its red colour comes from iron oxide, or rust. The sky is pink because the dust in the Martian atmosphere is red, from those rusty rocks.

(One interesting sidelight: the colour picture was made by superimposing three colour images – red, blue, and green – then

adjusting it until the overall colour seems right. The first tim around, the Martian sky was blue. After consulting their colou reference standard, the imaging team made corrections and th sky became pink. The crowd of reporters booed loudly when th colour change was announced – and got themselves criticised fo 'terrestrial chauvinism' by astronomer Carl Sagan.)

The first picture of Mars was a sensation. The first colou picture was a marvel. The pictures kept coming, one after another The scientists grabbed them for study, and the reporters' attentio turned elsewhere: to the search for life, which everyone knew was the main purpose of the Viking mission.

The main life-detection experiments were to start on the eighth day after the landing. A surface sampler – a scoop on the end of an extendable arm – would reach out and pick up some soil A sievelike lid would close over the sample. The arm would be pulled back over an inlet in the lander body. It would turn over and the scoop would be shaken. Fine particles of Martian soil would fall into the inlet for analysis.

The Tests

What sort of analysis? Put it this way: suppose you have the opportunity to land 160 pounds of instruments on a strange planet. You want to find out everything you can about that planet: all about its geology, its weather, its soil, and every other characteristic you can think of. There's a slim chance that something is alive on the planet. You don't know how big it is, or how much it differs from living things on earth. You don't have unlimited time, but you do have close-to-unlimited money to design instruments to detect that alive something. You know how to look for life on earth because the chemistry of terrestrial organisms is quite familiar. You don't know anything about the chemistry of life on the other planet, where nothing is quite like it is on earth. By what principle do you design your instruments to maximise the chance of finding that living thing?

The Viking scientists made what has been called the 'assumption of mediocrity'. It is an idea that runs like a red thread through all of SETI. In this instance, they assumed that life on earth is nothing special, but is so ordinary that life on another planet is likely to be pretty much the same. The starting point for biology on Mars was biology on earth.

On purely logical grounds, the assumption of mediocrity makes sense. If you don't know what you're looking for, look for

something familiar. Terrestrial scientists have just one example of planetary biology, life on earth, so they start with that one. But there are also some good biochemical reasons for the assumption. There are only a limited number of ways in which atoms can be put together into molecules – at least those molecules associated with life on earth. Essentially, life requires long, complex chains of atoms. No other atom forms chains the way that carbon does. Organic chemistry is defined as the chemistry of carbon, and 'organic' carries with it the connotation of life (although organic molecules can be produced without living organisms).

So one thing you do is look for organic molecules. The Viking instrument for detecting organic molecules in the soil was the gas chromatograph mass spectrometer, which had other missions as well (analysing the composition of the atmosphere, for instance). In the instrument, a sample of soil was first heated to nearly 400° Fahrenheit, boiling off gases and organic compounds. The compounds were then sorted out by mass and composition. The sample in the oven was then heated to 500° F, and the compounds that boiled off were sorted again. Eventually, the instrument gave a good reading of the kinds of molecules to be found in the region around it.

At the beginning, it was assumed that the gas chromatograph mass spectrometer would be of only passing interest in the search for life on Mars. While the instrument could detect organic molecules, the presence of organic molecules in Martian soil would not indicate that the soil contained living things. Even a totally dead planet can collect organic molecules because they can be formed without the help of living organism. Meteorites falling on earth contain fairly large concentrations of organic molecules. The same kind of meteorites fall on Mars, bringing organic molecules with them. So a positive result from the gas chromatograph mass spectrometer experiment would be far from conclusive.

Much more attention was focused on the life-detection package: three instruments packed into one cubic foot of space. Each instrument was designed to test a slightly different assumption about Martian life. Each of the tests was based on the principle that Martian life is chemically similar to terrestrial life, centring on carbon compounds. There was another basic principle: life on Mars, like life on earth, is probably based on water. It seems probable that some kind of liquid is needed by living organisms because chemical reactions go so well in solution. In theory,

several liquids could support life. In practice, it seems difficult to picture a kind of life based on anything but water. Perhaps there are ammonia oceans on a distant planet, with strange fishes swimming in them, but our search now assumes that other planetary oceans consist of water.

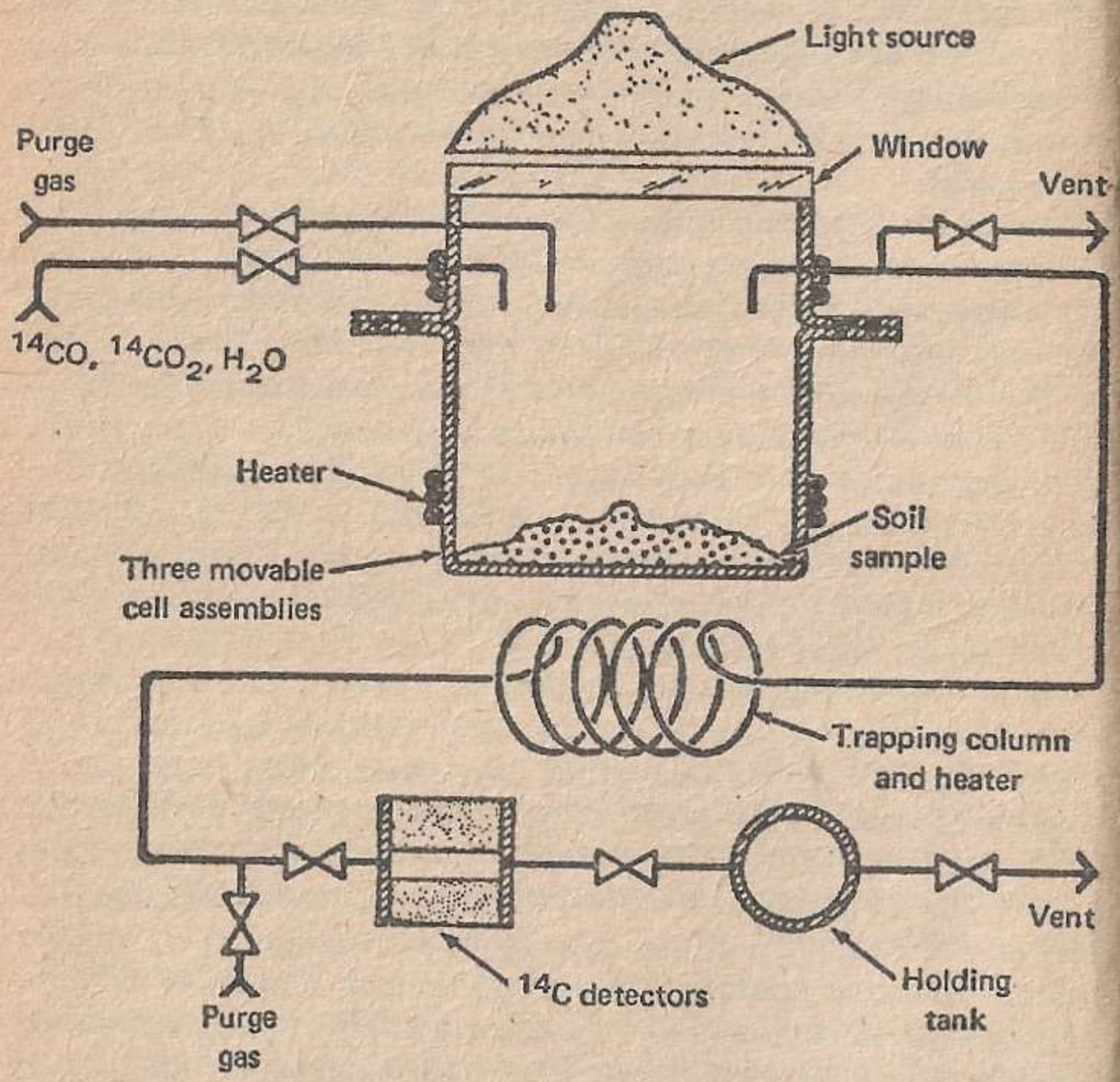


FIGURE 1 A schematic drawing of the Viking pyrolytic release experiment.

One instrument on Viking, the pyrolytic-release experiment, assumed that a living Martian organism would absorb carbon-containing gases from the atmosphere. (See Figure 1.) After the sample of Martian soil dropped into the pyrolytic-release test chamber, it would be incubated for five days in a natural Martian atmosphere, to which would be added carbon dioxide and carbon monoxide, both labelled with radioactive carbon-14. A xenon arc

lamp would provide artificial sunlight. After five days, all the gases would be flushed from the chamber, and the soil sample would be heated to vaporise whatever organic material might be present. The resulting vapours would be routed past a carbon-14 detector. Since all the other carbon-14 would have been flushed from the chamber (the reasoning went), any carbon-14 that remained would have to come from Martian organisms that had breathed the atmosphere and absorbed the test gases.

The pyrolytic-release experiment used no water. A second test, the labelled-release experiment, assumed that Martian organisms need some water to function. In this experiment, the sample of Martian soil was moistened with a small quantity of water containing organic molecules, again labelled with radioactive carbon-14. In essence, the experiment threw a piece of meat to the Martian organisms and waited to see if they burped. While the pyrolytic-release experiment would yield results only after the five-day incubation period, the labelled-release experiment would sniff constantly for gases given off by Martian organisms; there would be a reading once a day. The Martian soil sample would be incubated at 47° F and would be followed for more than a week. A set of detectors in the chamber would make a continuing search for radioactive gases. If a micro-organism fed on the nutrients and excreted carbon-containing gases such as carbon dioxide, the radioactivity of the atmosphere in the chamber would increase. The shape of the curve showing the increase would be quite important. If living organisms were excreting the gas, the curve would show continuing growth due to reproduction. A chemical reaction that produced the gas without the presence of living organisms would not show the growth typical of reproduction.

The third life-detection test, the gas-exchange experiment, did not use radioactively labelled compounds. As in the labelled-release experiment, the Martian soil sample would be wet. This time, the water would contain a rich broth of nutrients, nicknamed 'chicken soup' by the Viking scientists. A sensitive gas chromatograph would monitor the chamber for traces of gases that might be emitted by a living organism which fed on the broth. At the beginning of the experiment, the water would be kept below the level of the soil sample. Later, the water level would rise to wet the soil. All the while, the gas chromatograph would search for oxygen, methane, carbon dioxide, and other gases that are associated with life on earth.

It was assumed that life on Mars, if it existed, would be tough,

tenuous, and rare. The Viking scientists were not expecting herds of Martian animals to wander by, or fields of Martian plants. Sure there were signs of water flow on Mars, but that was a balmier time. Things are tough on Mars now, at least by terrestrial standards. Not only is the atmosphere thin, but it also is 95 per cent carbon dioxide, with only a few traces of the water, oxygen, and nitrogen that are essential to life on earth. Mars is cold, too. The day that Viking landed, it recorded a temperature of −25° F at Chryse, in a temperate part of the planet at a warm time of the year. In addition, the thin atmosphere of Mars does not screen out lethal ultra-violet radiation, which is absorbed by the ozone layer in the earth's atmosphere. Ultra-violet radiation is harmful to living organisms.

Even given all these handicaps, we can work out a scenario that would allow life to exist on Mars. Life could have evolved early, during the more favourable era when water flowed freely. As the water disappeared, living organisms could have slowly developed protective mechanisms; existing under the surface, hoarding the water that was available, and getting protection from ultra-violet radiation from the covering layer of soil. There are organisms on earth living under conditions of comparable severity – in boiling springs and the dry cold of the poles. Some of the Viking scientists were optimistic about life on Mars and some were pessimistic, but none of them really knew what to expect from the life-detection experiments.

After some initial trouble with the soil sampler (a pin that should have been released wasn't), the life-detection experiments began on schedule. The results were as dramatic as anyone could imagine. As soon as the first dose of nutrient solution was added to the soil sample in the labelled-release experiment, the detector picked up a steep increase in radioactivity. Gases that included radioactive carbon from the nutrients were being released at about four times the rate that would have been expected from soil on earth. The gush of gas did not last long; it stopped after the first 70 hours. When some more nutrient solution was added, there was another brief spurt of gas release, followed by another drop in activity.

As for the pyrolytic-release experiment, Norman H. Horowitz of the California Institute of Technology, who designed the instrument, expected a reading of about 15 counts per minute from barren, lifeless soil. The actual reading was 96 counts per minute. That was a higher reading than had been obtained in test runs with soil from the dry valleys of Antarctica, which are

believed to be the most barren places on earth.

The results of the gas-exchange experiment were also unusual. In the first stage of the experiment, when the nutrient solution was not in contact with the soil sample, there was a quick burst of oxygen – fifteen times the amount that could be expected from soil on earth – and a slow, steady release of carbon dioxide. When the level of the solution was raised to wet the soil, no more oxygen was released, and the amount of carbon dioxide actually dropped.

The Viking scientists circled cautiously around those results, trying to make some sense out of them. Basically, there are two competing explanations for the Viking test results. They could be caused by some sort of chemical reaction that has nothing to do with living organisms. Or they could be caused by living organisms in the Martian soil. Chemistry or biology: the scientists had to choose one or the other.

Between the day that Viking I landed and the day in May 1977, when the life-detection experiments on both Viking landers were turned off, those experiments were run again and again in an effort to get a clear-cut answer. Sometimes the soil was heated to several hundred degrees to see whether this kind of heat sterilisation would affect the response. Sometimes heat sterilisation at lower temperatures was tried. On some runs of the pyrolytic-release experiment (the dry one), water was added to see how its presence would affect the results. The Viking II lander, which put down safely at a more northerly and presumably wetter region of Mars, went through the same round of experiments. Working from earth, the Viking scientists dug a foot-deep trench to get a soil sample from deeper down, where ultra-violet radiation could not penetrate. They shoved a rock aside to get a soil sample. They ran shorter and longer cycles of the experiments under a number of different conditions, to try to end the uncertainty. In the end, a degree of uncertainty remained.

Consider one experiment, done with the pyrolytic-release apparatus on Viking I. Team leader Norman Horowitz first moistened the soil sample and then heated the sample to drive off the water. By then, early in 1977, it had been established that either adding water or heating reduced the response. Doing both, Horowitz reasoned, should lower the response to zero.

Instead, there was a significant radioactivity count from the sample. That result seemed to be a vote for a chemical cause, rather than biology. Water is assumed to be essential to life. Yet

adding water to the Martian soil sample reduced the response, while removal of the water by evaporation increased it. In addition, heating would presumably damage Martian microbes; yet there was a high level of activity after the heating.

But there were the results of the gas-exchange experiment, in which Martian soil that was exposed to water vapour gave off a lot of oxygen quickly. Adding water could promote the release of oxygen without the presence of living organisms if the Martian soil is rich in oxygen-containing compounds. The fact that there is little or no oxygen release if more water is added a few days later supports the chemical explanation: after the initial chemical reaction, there was no more oxygen to release.

It seems simple and consistent. But some scientists, such as Bernard Levin, head of the gas-exchange experiment team, detected inconsistencies. If all the responses were due to reactions of water with oxygen-containing compounds, Levin said, there should have been no activity in the pyrolytic-release experiment when the soil was first wetted and then heated. If the activity was due to chemistry, Levin said, then Martian chemistry is considerably more complicated than terrestrial soil chemistry.

After a while, the weight of opinion began to tip towards the chemical explanation. Taken alone, the three life-detection experiments might be considered to have given equivocal results. But the readings from the gas chromatograph mass spectrometer carried a great deal of weight. That instrument looked repeatedly for organic molecules on Mars. It found none – none at all, an astounding result.

Where Have All the Organics Gone?

In effect, the gas chromatograph mass spectrometer was looking for bodies. On earth, soil is rich with the remains of microbes which have lived and died, leaving their organic material to mark their existence. There are no such bodies in Martian soil – at least as far as the gas chromatograph mass spectrometer can tell. And it is a sensitive instrument.

'Our instrument could have detected dead organisms anywhere from a hundred to one thousand times fewer in number than there are in poor earth soils, like the soils of Antarctica,' said Klaus Bierman of the Massachusetts Institute of Technology, the designer of the instrument. 'We did not find any organics. There doesn't seem to be a mechanism that accumulates organics on Mars.'

The puzzling thing about the Martian organics is their complete absence. As stated earlier, organic molecules do not have to come from living organisms. Carbon-rich meteorites contain organic molecules that have formed naturally, and these meteorites have rained down on Mars for eons. Where have these organics gone?

A numer of theories have been floated to explain the missing organics. They could have been destroyed in some way by the huge dust storms that sweep across the face of Mars. Or they could have been eaten by Martian microbes. After all, Mars is a poor planet by terrestrial standards. If it does have microbes, they might not have the luxury of being left alone after death. Martian micro-organisms may have developed into efficient cannibals under the pressure of the harsh Martian environment. Or they may have developed hard shells to lock in water and keep out radiation, shells that would make them undetectable.

Many of the Viking scientists now believe that the missing organics were oxidised. The thin Martian atmosphere allows ultra-violet radiation to bathe the surface. Ultra-violet breaks Martian water into hydrogen and oxygen. The oxygen combines chemically with the organic molecules, destroying them. So the theory goes.

No Life on Mars?

When Viking project scientists met in Boston in September 1977, the consensus was that life had not been found on Mars. If there had been a vote at the meeting, the chemical explanation would have won. The chemistry of Mars may be complicated, but the assumption is that the Viking results can best be explained by chemical reactions with a soil rich in oxygen-containing compounds.

Of course, we could say that if the chemistry of Mars is unusual, its biology is also likely to be unusual. But all things being equal, scientists accept the explanation that challenges the fewest accepted concepts. The concept of strange Martian soil chemistry is easier to defend than the concept of a strange Martian biology. In addition, conservatism is important in exobiology, which has climbed to scientific respectability only in the past few decades. The conservative interpretation of the Viking results is the chemical interpretation. No one can deny that there is a good amount of data to support that interpretation.

Norman Horowitz pointed out that the readings from his

pyrolytic-release experiments which seemed to indicate the presence of life had continued even after the soil samples were sterilised by heating. Horowitz said that the failure of heat sterilisation to stop the release of radioactive gases was a telling sign against the biological explanation. If Martian organisms do exist, Horowitz said, they have been bred by evolutionary pressure to survive in the cold environment of Mars. Therefore, Martian microbes are presumably much more sensitive to heat than terrestrial microbes, and their activity should have been stopped by the intense heat-sterilisation process. The fact that activity had continued after heat sterilisation showed that the results of the pyrolytic-release experiment 'couldn't be biological', Horowitz said.

Vance I. Oyama, the scientist in charge of the gas-exchange experiment, had the same phenomenon to report and the same interpretation. Activity had continued even after the Martian soil sample had been baked enough to kill terrestrial microbes. The fact that the observed reaction was 'insensitive to heat sterilisation tends to reduce the probablity that it is biology', Oyama said.

But the vote for the chemical explanation was not unanimous. Aside from the fact that scientific issues are not settled by vote, belief in a possible biological explanation was kept alive by a few scientists in the Viking Project. One of them was Gilbert Levin. Levin said that he had tried to reproduce the Martian results on earth using many different oxygen-containing compounds of the kind that were supposed to be on Mars but 'could not find equivalent reactions'. Levin has been one of the Viking scientists who is most strongly inclined to the biological explanation. (Horowitz, by contrast, is one of the most determined sceptics. When, during the early days of the mission, he wavered slightly towards the thought that there might be life on Mars, the stock of the biological explanation went up a few points. Later, Horowitz went back to his original position.) Now Levin was saying that the labelled-release experiment had produced the same results on both landers at two different Martian locations. To him, those results seemed to be interpretable as 'unequivocal evidence of life'.

But the others kept coming back to the gas chromatograph mass spectrometer. Where are the organic compounds scientists would expect from living organisms? Their absence seemed to be the clincher for the chemical explanation.

But that doesn't close the case entirely. The maddening thing

about the Viking results is that they have not really settled the question of life on Mars. All the scientists are talking in terms of probabilities, not certainties. Oyama and Horowitz believe that it is highly improbable that life exists on Mars. Levin believes that the possibility is still open. In Scottish jurisprudence, there is a verdict that falls somewhere between guilty and not guilty: not proven. That's not a bad verdict for the Viking mission, since the chemical explanation presents almost as many difficulties as the biological explanation. Maybe the best summary is a statement that Horowitz made in talking to an interviewer: 'There's no question that there is something going on that we don't understand.'

1984: Back to Mars?

The only way to get a good answer is to go back to Mars, which is something the scientists would love to do. Money is the problem. When, early in 1977, the National Aeronautics and Space Administration's budget was revised to include a bare $10 million to keep the idea of future missions to Mars alive, the Viking scientists reacted with a sort of shocked jubilation. They had expected to be shut out entirely. At the Jet Propulsion Laboratory, planning began for a Mars mission in 1984, just about the first realistic opportunity. The 1984 mission would have two landers, each with a vehicle that could carry laboratories for 100 miles or so. (See Figure 4.) In addition, the spacecraft would also carry penetrators, which would rather resemble giant thumbtacks. The penetrator would slam hard on to the surface of Mars. The point of the tack would shoot about ten yards into the ground. It would be connected to the flat head of the 'tack' by a wire that would carry data about conditions underground. The data would be radioed back to the orbiting part of the spacecraft.

The rover-penetrator mission would be the prelude to a later voyage whose primary mission would be to bring back a sample of Martian soil for analysis – not back to the surface of the earth, but to an orbit around earth where scientists could carry out the analysis without fear of contaminating our planet with organisms that might be in the Martian sample. The proposed 1984 mission would cost an estimated $700 million in 1977 dollars, and more when inflation is taken into account. The soil-sample-return mission would cost in the neighbourhood of $1 billion.

Neither mission will fly, at least for the foreseeable future. The

joy of the Viking scientists over the 1977 appropriation to plan a follow-up mission turned out to be premature. By 1978 it was clear that the Carter administration was not in favour of an expensive return mission to Mars. The $30 million to $40 million that would be needed to start planning for a 1984 Mars mission was not in the budget that the administration submitted to Congress in January 1978. More than that, it was clear that the Carter administration was not making any large-scale plans for planetary exploration. Money would be doled out, enough to keep the programme alive, but spending would be grudging and every penny would be pinched. At least, that was the impression that space scientists received about the administration's attitude.

There was, of course, very little grumbling about the Mars mission decision, at least in public. On a practical level, grumbling would do no good. Neither the administration nor Congress was in a spending mood for space programmes. Rather than pushing for bigger and better missions in space, scientists were trying to prevent existing programmes from being cut back. The open-ended, liberal spirit of the 1960s had given way to the more cramped spirit of the 1970s.

But the scientific reaction was also attributable to the results of the Viking mission. Those results seemed to indicate that there is only a slim chance, at best, that life exists on Mars. If there had been a scientific consensus that life on Mars is probable, the pressure for a follow-up mission to Viking would be much greater. As it is, space scientists are not exerting that pressure. An ambitious new mission to Mars is a tempting prospect, but such a mission does not make practical sense if the chances of dramatic findings are small. Martian life would be the most dramatic finding at all – probably the only finding that could persuade Congress and the administration that a billion-dollar mission should be undertaken. The unwillingness of the scientific community to press for a Martian follow-up mission speaks quite clearly about the prevailing assessment of the Viking mission. By not asking urgently for money, the scientists are implying that Viking did not find life on Mars.

But this does not mean that planetary scientists have given up all plans for going back to Mars. Sooner or later, a new Mars mission will be proposed with enthusiasm. Planetary geologists still want to study Mars as a planet; meteorologists want to study its weather more closely. And Mars missions also can expand the slender data base on which exobiology is founded.

Exobiologists have only one planetary system to work with. They have assumptions about the probability of planetary systems around other stars and about life in such planetary systems, but they have only one system in which life is known to exist. In fact, they have only one *planet* on which life is known to exist.

By current standards, Mars is a borderline case for life. If there should happen to be living organisms on Mars, proof of their existence would change the complex chain of calculations that exobiologists use to estimate our chances of making contact with another intelligent civilisation. The changes might not be profound, but they would be significant. If there is not life on Mars, the calculations would also be influenced. Even though the consensus is that Mars is lifeless, that belief falls short of certainty. And scientists crave certainty.

But suppose that against all the odds there is life on Mars. It could be that Martian organisms have an unexpected biological twist, some evolutionary oddity that indicates the existence of an unearthly pathway by which life can evolve. That knowledge would also change the odds for the existence of life on other planets around distant stars. It would, in fact, revolutionise exobiology, and it would add evidence to support a long-term search for signals from extraterrestrial civilisations. The belief that we will go back to Mars, sooner or later, is hard to resist.

CHAPTER TWO

Where We Come From

Viking went to Mars because of a human vision of what Mars is like. You cannot plan to visit a place unless you believe that it is, indeed, a place. In the beginning, Mars and the other planets were things, not places. They were only points of light in the heavens. (The planets got their name, Greek for 'wanderers', because they are moving points of light among the fixed points of the stars.) The earth was the only place. Later, in the youth and adolescence of modern science, the planets did become places. The pendulum swung far. The planets not only were places, they were also earthlike places, very easy to get to and certainly habitable – if not by humans then by beings similar to humans.

We can trace an intellectual path from the early views of the earth and the universe through what now seem to be the romantic days of science and on to today's rigorous world-view. But we should remember that this road is built by working backwards. The natural philosophers of the past could not appreciate that their ideas would someday be judged by people with our view of the universe. Modern scientists pick and choose among the ideas expressed over millennia, winnowing out all but those few concepts that fit the modern world-view. As Jorge Luis Borges said in his essay on Kafka's precursors, 'The fact is that every writer *creates* his own precursors. His work modifies our conception of the past, as it will modify the future.' In the same way, modern science continually modifies its judgements of the past as new concepts arise.

The major effort of modern science is to banish wonder from the universe. (Chance cannot be banished because quantum mechanics says that the universe is unpredictable on the most basic level.) In the beginning, the world was full of wonder. The earth was an almost unimaginably big place set in the middle of a universe that was almost beyond understanding. If anyone thought about it, the earth was regarded as the sole repository of life in a universe consisting of dots of light circling in complex patterns.

Beginnings

But from today's vantage point, we can find the beginnings of a belief in extraterrestrial life at the very start of Western science, which seems to have begun in Greece. The first great school of ancient Greek science arose in Ionia, which occupied a narrow coastal strip of what is now western Turkey and the neighbouring Aegean Islands. Miletus, one of the twelve major cities of Ionia, was the home of the first great natural philosophers. The first of the Milesian philosophers was Thales, who lived in the sixth century BC. Anaximander, who followed Thales, entertained the idea that there might be other worlds than the earth. And in the fourth century BC, the Epicurean philosopher Metrodorus wrote, 'To consider Earth as the only populated world is as absurd as to assert that in an entire field sown with millet only one grain will grow.'

That statement could stand as a succinct summary of today's most prevalent view about life in the universe. However, it was more a passing view than a central tenet of Greek natural

philosophy. A major interest of the ancient Greek intellectuals was the effort to organise the universe along severely logical lines. Pythagoras organised the world by numbers: square numbers, triangular numbers, pentagonal numbers, in ordered relationships. The stars and the planets circled the earth in perfect circles, another orderly relationship.

There was a fire at the centre of the universe. Around that fire circled the earth, the moon, the sun, the five known planets, and the stars. When observations indicated that the orbits of the planets were not perfect circles, a scheme was developed in which the orbits were described as a system of smaller circles around larger circles. Cycle and epicycle; postulate enough of them, and any motion of any heavenly body fits the theory.

From our vantage point, we can pick out the dissenters from this logical but incorrect world-view. In the third century BC, Heraclides of Pontus argued that the observations could be explained by saying that the earth is rotating on its axis. Aristarchus of Samos, who was born about 75 years after Heraclides, published a book, long lost, which included the hypothesis that the stars and the sun do not move, but that the earth orbits the sun.

At the time, the heliocentric theory was a minor curiosity. The world listened to Aristotle, who explained the case for a geocentric universe quite logically: since the gods are eternal, the heavens must be eternal; the heavens were a rotating sphere, with the earth at the centre of the sphere.

Some 1800 years later, Copernicus was aware that his heliocentric theory was a revival of Aristarchus's hypothesis. For most of that long period, the heliocentric theory was pushed out of sight. The stubborn faith in the belief that the earth is the centre of the universe can be explained only partly by the technical difficulties of working out a heliocentric theory. (The planets move in ellipses, not circles, which complicates the calculations.) The real problem was an inability to grasp the nature and the size of the universe. It is a problem that still bedevils SETI. Most non-scientific people, and some scientists, cannot comprehend the vast distances of the universe.

Looking out at the twinkling stars, it is hard to realise that if you started for the nearest of them using the most advanced machines now available, you would die long before you made even a decent start. Even at the ultimate speed, the speed of light (and of all other electromagnetic radiation, including radio waves), signals take decades or centuries to reach our nearest

neighbours in space. Beyond those neighbours, the universe really begins. If man is the measure of all things, the universe is too vast to comprehend. We can understand it only by adopting a frame of reference that is quite literally inhuman.

A Universe Too Vast to Comprehend

Such a frame of reference is not easy for the human mind to adopt, even in an age which is impregnated with the measurements of modern technology. It was simply impossible to even the keenest intelligence of a non-technological civilisation. Most of Aristarchus's works are lost (his reference to the heliocentric system survives in a work by Archimedes), but we do have a book in which he attempted to work out the sizes of the sun and the moon. On the basis of his calculations, he said that the sun is eighteen to twenty times more distant from the earth than the moon, and that the diameter of the sun is between eighteen and twenty times greater than the diameter of the moon. The distances and sizes that Aristarchus described may have seemed enormous to him. In fact, his estimates fell short by many thousandfold. The flaw was not in the methods that Aristarchus used. (Not long afterwards, another Greek scientist, Eratosthenes, used similar methods to make a remarkably accurate estimate of the size of the earth.) More likely, Aristarchus simply was not ready to deal with a solar system of huge bodies and vast distances. The universe was growing larger, but it was still a small, intimate place of modern standards.

Here and there in Hellenistic and Roman literature, the concept of life elsewhere in the universe is mentioned. In the first century BC, Lucretius wrote that 'it is in the highest degree unlikely that this earth is the only one to have been created' and that 'in other regions there are other earths and various tribes of men and breeds of beasts'. Three centuries later, Plutarch speculated about the suitability of the moon for life. Again, the thought is of human life in a universe built to human scale. The universe was a comfortably manageable home.

When Rome fell, the universe became even smaller. After the initial chaos of the barbarian conquests, a lively intellectual life was established in Europe. Medieval times were not the 'dark ages' we were taught about in school. Medieval art and the architecture that culminated in the great Gothic cathedrals tell their plain story of intellectual vigour. But it was not the questing, outward-looking vigour of the inquisitive scientific mind. A

closed, stable society seemed best. A plurality of worlds would be an embarrassment, especially in theology. Earth had its Saviour. Other inhabited planets would either require some attention from our Saviour or a plurality of Saviours. It was an uncomfortable choice, best avoided by thinking only of Earth.

At this point in the conventional history, there is a description of Europe's awakening from its intellectual lethargy to resume its march towards modern science and technology. In the accepted wisdom, medieval times were an unfortunate lapse from the normal state of humanity, which features a continual striving for economic growth and control over the physical world. But as we have seen, it is the restless spirit of modern science that appears to be unusual in human history. For some reason, a few people began looking at the world in a different way about 400 years ago. The tools they had for looking at the world were in no way new or different. Those tools would now be used to weigh, measure, and conquer nature in a way that had not been thought of before.

Galileo's Intellectual Giant Step

The single figure who is most identified with the birth of modern science is Galileo Galilei. Some predecessors of Galileo had chipped away at the foundations of the medieval system. In the middle of the sixteenth century, Nicolaus Copernicus revived and expanded the concept of the heliocentric system, removing the earth from the centre of the universe. Not long afterwards, Johannes Kepler added the important information that the planets orbit the sun in elliptical, not circular, paths. But both Copernicus and Kepler were deeply rooted in the medieval way of thinking. Copernicus believed in the systems of cycles and epicycles, heavenly spheres within spheres. Kepler conceived of a logically organised solar system in which the orbit of each planet was related to one of the regular solids – the cube, the octahedron, and so on. Kepler also tried to relate the orbit of each planet to musical notes, so that there would literally be music of the spheres.

Galileo took the giant intellectual step of looking at the heavens without such preconceptions. Anyone could have done the same thing, just as anyone could have started modern technology. The Romans had the steam engine and the ancient Chinese had the rocket. They treated them as toys.

In the same way, peddlers were hawking telescopes in the

streets when Galileo decided that these gadgets were something more than toys. The available instruments were not up to his standards, so Galileo made his own. He turned the telescope on the moon and saw mountains and craters. He turned it on the Milky Way and saw it resolve itself into individual stars. He turned it on Jupiter and detected four moons – the Galilean satellites, they are still called. He turned it on Venus and found that the planet showed phases like the moon. He turned it on the sun and saw sunspots, evidence that the sun rotates.

The evidence that the bodies in the sky are places, not abstract points of light, was there for anyone to see, and the evidence for the heliocentric theory was overwhelming to anyone who had eyes to look. Most scientists chose not to look. There is a celebrated story of Galileo offering his telescope to a critic, so that he could convince himself. The offer was declined because the medieval mind did not regard the physical world as the most important factor. There was a higher truth, dictated by logic and faith. Galileo's heresy, for which he was condemned to penance, was to challenge this higher truth.

A new spirit was abroad. Even before Galileo made his astronomical observations, Giordano Bruno, a Dominican monk, could write, 'Innumerable suns exist. Innumerable earths revolve about these suns in a manner similar to the way the planets revolve around the sun. Living beings inhabit these worlds.' Bruno was burned at the stake for heresy, not so much because he championed the Copernican theory as because of his fierce independence and refusal to compromise.

It was the beginning of a period of florid speculation about the universe (although, it should be noted, the word 'universe' has a far different meaning to our infinity-minded age than it did when things were on a smaller scale). The old bonds imposed by religion were broken, and the new, equally strict bonds of modern science had not yet been forged. Imagination was free to run loose. Christiaan Huygens, a Dutch astronomer who discovered the rings of Saturn and a new satellite of Jupiter which he called Titan (we will hear more of it later), writing towards the end of the seventeenth century, concluded quite matter-of-factly that there are planets circling the stars, even though the stars were too distant for their planets to be seen from earth. It is equally probable, Huygens went on 'that these great and noble bodies have somewhat or other growing and living upon them, though very different from what we see and enjoy here'. Nobody burned Huygens or forced him to recant. Times were changing.

Cyrano de Bergerac wrote about a voyage to the moon, although he was unscientific about the mode of propulsion. Bernard de Fontanelle wrote in the eighteenth century about the inhabitants of other planets in the solar system. Two of the greatest English scientists, Isaac Newton and William Herschel, believed that the sun was inhabited.

The Moon Hoax

By the middle of the nineteenth century, there was a more or less casual acceptance of the possibility that life existed on other planets in the solar system. That was proven by the Moon Hoax of 1835. The *New York Sun* printed a series of reports, allegedly written by Herschel, describing in great detail observations of living creatures on the moon – lunar mountains embedded with sapphires, rubies, and amethysts, moon creatures eating melons, and the like. The hoax was soon exploded, but the point is that people were ready to listen and believe.

Mostly, they were ready to listen to stories about Mars. Volumes could be – and have been – written about the fascination that Mars has held for believers in extraterrestrial life. William K. Hartmann and Odell Raper, in an official NASA history of the Mariner 9 mission, described 'the conception of Mars that was transmitted by astronomers to other intellectuals of the early 1800s:

> Mars was a planet with oceans and lakes, dry reddish land, clouds, polar snows, a day of some 24 hours – in short, it was a planet much like earth. In view of the momentous import attached by us moderns to the search for life in the universe, it may come as some surprise to realise that Herschel and other scientists of his time almost casually assumed that Mars and other planetary bodies were inhabited. This was before Darwin gave us the idea of the long struggle towards sentient life; thus scientists of the nineteenth century inherited the idea of 'the plurality of worlds', with a Mars already teeming with creatures and a reasonably pleasant environment well suited for them.

Much of the later story of Mars centres on one Italian word: *canali*, which can be translated either as 'channels' or 'canals'. The word was first used in 1869 by Father Pietro Angelo Secchi, who published the earliest-known colour sketches of Martian features. Father Secchi described some streaky Martian markings

as *canali*. It is not known whether he wanted to say 'channels' or whether he thought that there were canals on Mars. Nine years later, another Italian astronomer, Giovanni Schiaparelli, used the same word (and its singular, *canale*) to describe a network of lines which he said he had observed on Mars. Schiaparelli's map of Mars, showing the *canali* clearly outlined, set off a controversy that lasted the better part of a century.

Some astronomers said they could see the *canali*; some said they could not. There was the question of what could be seen when the viewing was excellent and what could be seen on those infrequent occasions when the viewing was better than excellent. Scepticism abounded. 'I can't believe in the canals as Schiaparelli draws them,' wrote E. E. Barnard, an American astronomer with an excellent reputation for observation, in 1894. '. . . I verily believe – for all the verifications – that the canals as depicted by Schiaparelli are a fallacy and that they will be so proved before many favourable oppositions are past.' (An opposition is the time when the earth and Mars are closest together in space.)

The Romance of Mars

Then along came Percival Lowell, of the Boston Lowells, who began observing Mars from an observatory he founded in Flagstaff, Arizona, towards the end of the nineteenth century. If Barnard could not see the canals, Lowell certainly could, better than anyone else has ever managed to see them. And he could not only observe the canals, built with 'wonderful directness', but he could also explain the reason for their existence. Mars was an old dying planet that was losing its water. Its once-prosperous inhabitants had become engineers on a huge scale.

'Irrigation, and upon as vast a scale as possible, must be the all-engrossing Martian pursuit. So much is directly deducible from what we learned at Flagstaff of the physical condition of the planet.'

Lowell's vivid picture of a dying Martian civilisation made a lasting impression on the public. It gave birth to one book of permanent value, H. G. Wells's *The War of the Worlds*, in which the earth was invaded by Martians who were bent on conquering our planet because theirs was becoming uninhabitable. In Wells's story, Martian technology was too advanced to be fought off by mankind, but the Martians were defeated when they died of terrestrial infections. Some forty years later, Orson Welles demonstrated just how strongly people believed that there might

be intelligent life on Mars. His eerie radio dramatisation of Wells's story set off a nationwide panic.

If the public believed in Martian civilisations, scientists did not. Evidence against Lowell's thesis was accumulating rapidly. At every Martian opposition, telescopes were turned on the red planet. Most of the observers saw nothing resembling an organised network of canals. Instead, they saw what one astronomer described as 'a prodigious and bewildering amount of sharp or diffused natural, irregular detail . . . it was at once obvious that the geometrical network of single or double canals discovered by Schiaparelli was a gross illusion'.

Other measurements of Mars slowly destroyed the belief that it was a twin of earth. In the 1920s, temperature measurements made from earth found that the mean Martian temperature is −40° F, which would make life on Mars either quite difficult or impossible for advanced organisms. In the 1920s and 1930s, another series of observations found no detectable water vapour or oxygen in the Martian atmosphere, another telling point against the existence of a Martian civilisation. Gradually, a new picture of Mars emerged, a picture of a cold, almost waterless, almost oxygenless planet with only a wisp of atmosphere. The romance of Martian civilisations died as the scientific data accumulated. The possibility of life on Mars remained open, but the rules of the game had changed.

To scientists it was increasingly clear that if there was life on Mars, the organisms would have to be quite hardy by terrestrial standards and probably had to struggle even for minimal survival. It was a picture that the public, even some educated segments of it, failed to accept. During the opposition of 1924, the United States Army and Navy actually ordered their most powerful radio stations to stop sending for a time, to help in a scheme to detect possible messages from Mars. There were none, of course, but Martians made juicy reading, and their supposed civilisations were a staple of the tabloids and pulp magazines of the 1930s. In 1938, a Canadian astronomer, Peter M. Millikan, began a scientific paper with the weary observation: '. . . so much nonsense has been written about the planet in various branches of literary endeavour, that it is easy to forget that Mars is still the object of serious scientific investigation'.

The evolution of the human view of Mars is instructive. First Mars was just a wandering light in the sky. Then it became a place, a globe like the earth – so much like the earth that we peopled it with beings like ourselves and a civilisation like ours.

Then, slowly, scientific studies turned Mars into what it is now: a planet that has some resemblance to earth, but is different in a number of basic ways, and one that certainly cannot support anything resembling human life-forms. Our current view of Mars is clear, accurate, and rather bleak.

While concepts of Mars were changing, so were concepts of the universe, and in much the same way. The universe was growing larger and more unhuman. In the beginning, it was just a collection of lights in the sky. When astronomers realised that the stars were not merely points of light but instead are bodies like the sun, they began trying to determine the distances to the stars.

Measuring the Universe

And just as mankind had imagined that Mars must be a homey, earthlike place, astronomers believed that the stars could not be all that distant. It seemed natural to believe that the universe was built to human scale. It was only as measurements became more accurate that the vast, unhuman dimensions of the universe emerged. Even when the measurements were made, there was a major controversy about the size of the universe, a controversy due largely to the inability of even trained scientists to understand just how small the human race, its planet, and its sun are in the cosmic scheme of things.

One way to judge the distance to a star is by its brightness. If a star appears very bright, it seems reasonable to assume that it is closer to earth than a dim star. But this technique works only if all stars are identical. They are not. Some stars glow dimly. Others blaze brightly, burning with a blue-white heat. A bright star that is far away and a dim star that is close by will have the same apparent brightness.

A method other than judging the brightness of stars is to measure the movement of a star in relation to other stars. In reality, it is not the star that is moving, but the earth. In its orbit around the sun, the earth travels a fairly large distance. A nearby star seen from the earth appears to be moving against a background of more distant stars. The apparent shift of a star due to the earth's motion is called the star's parallax. In 1838, German astronomer Friedrich Wilhelm Bessel made the first measurement of parallax to determine the distance of a star from the earth. Other measurements followed, but the use of the method was limited because it works well only at fairly short

range. The more distant a star, the less its apparent motion. Beyond a distance of thirty light-years, parallax measurements become more and more uncertain. Only a few hundred stars out of the myriad visible from earth can be placed by parallax measurements.

During the nineteenth century, astonomers used a combination of parallax measurements and brightness measurements to determine the distance of a number of stars. The method, although tedious, was successful because a classification of stars by type had been worked out. An astronomer would determine the distance from the earth of a star of a given type by measuring its parallax. The astronomer would then find a star of the same type that was far more distant and would compare its apparent brightness with the brightness of the star of known distance. The comparison of apparent brightness with actual brightness would give the distance of the star.

The task of determining distances would be infinitely easier if there were some characteristic of a star that was directly related to its brightness. Given such a relationship, the astronomer could simply measure the characteristic, determine the actual brightness of the star, and so place it accurately.

Such a characteristic was discovered early in the twentieth century by Henrietta S. Leavitt, an assistant at the Harvard Observatory. The observatory was making a systematic search for variable stars – so called because their light grows dim and then bright in a regular cycle. Miss Leavitt was studying a class called Cepheid variables, so named because one of the most noted is in the constellation Cepheus. She found that the period of fluctuation in a Cepheid variable's light output is directly related to its brightness: the brighter they are, the slower the cycle from dimness to brightness. By timing the cycle, an astronomer could determine the actual brightness of a Cepheid variable. By comparing the apparent brightness to the actual brightness, the distance of the star could be determined.

Miss Leavitt's discovery came along at a critical time in a long-standing debate about the structure of the universe. The debate goes back at least as far as the Greeks. On cloudless nights, they could easily see a band of light running across the sky. They called it *galaxias kyklos*, the 'milky circle'. We call it the Milky Way.

In the fifth century BC, Democritus wrote that the Milky Way might be made of stars. Galileo found that it was when he trained his telescope on it. A little more than a century later, an English

philosopher named Thomas Wright wrote a book theorising th
the stars in the Milky way were in a galaxy shaped like a gri
stone, with our sun near the centre. Wright added that
galaxy probably was only one of many – an idea that was echo
by Immanuel Kant just a few years later.

Wright's book caught the attention of one of the great astr
omers of the time, William Herschel, royal astronomer
George III. With royal backing, Herschel was able to constr
the finest telescopes in the world, and to embark on a systema
programme of observations. Herschel found that the conce
tration of stars lessened slowly if he looked along the plane of t
Milky Way. If he looked perpendicular to the Milky Way, t
concentration of stars was lower. Therefore the galaxy w
indeed disc-shaped. Towards the end of the eighteenth centu
Herschel had a picture of the galaxy rather like two fried e
put back to back: thicker at the middle, with the stars thinni
out towards the edges.

But Herschel and other observers saw more than stars. The sk
also contained nebulae, which at first appeared to be just sme
of light. In the middle of the nineteenth century, an Iri
astronomer, Lord Rosse of Parsontown, built himself the larg
telescope on earth and found that at least some nebulae do have
structure. They appeared to be pinwheels of gas. By 1888, o
catalogue listed 8000 nebulae, more than half of them the kind
spiral galaxy that Lord Rosse had found.

No one quite knew what to make of the nebulae. They cou
be listed as spiral galaxies, as globular clusters, or by their oth
shapes, but their place in our galaxy was uncertain. What wa
certain, at least to the great majority of astronomers, was th
general scheme of things. The galaxy was pretty much as Hersch
had described it – other observers had confirmed his work on th
shape of the galaxy – and our sun was close to the galactic centr
There was an occasional suggestion that the nebulae might b
'island universes' the term used by Kant to describe othe
galaxies like our own, but the idea did not take root.

The Great Galaxy Debate

Enter Harlow Shapley, an American astronomer. A Dan
Ejnar Hertzsprung, had done the work needed to make Mis
Leavitt's discovery about Cepheid variables into a usabl
measuring rod. Shapley used the celestial yardstick to study th
distribution of globular clusters. He was able to show that the

med a kind of halo around the Milky Way, and, by combining
tance and direction information, he obtained a three-
ensional picture of their distribution. They seemed to be
tred on a point lying in the direction of Sagittarius, tens of
usands of light-years distant from our sun. Shapley concluded
t this point, not the sun, was the centre of the galaxy. In a
gle stroke, Shapley had not only expanded the dimensions of
galaxy tenfold, he had also demoted the sun from the central
ition in the universe.

Shapley's estimate of the size of the galaxy later had to be
duced. He did not know that there are clouds of dust and gas
t make the light from distant stars look dimmer, and thus he
er-estimated the distances. His basic picture of the shape of the
laxy, a picture that put the sun near one of its edges, has not
n changed. But on one critical point, Shapley was dramatically
ong. He refused to believe that the globular clusters, the spiral
laxies and other nebulae were island universes, galaxies on the
me scale as ours scattered through almost unimaginable
panses of space.

Many others shared his views. Battle lines were drawn within
e community of American astronomers, pretty much on East-
West lines. California was the bastion of pro-galaxy feeling, while
e East Coast was the seat of scepticism. The debate went on
hrough the teens of the century and into the early twenties.

The debate ended on 1 January 1925, at an astronomical
eeting which heard a communication from Edwin Hubble, who
d been observing nebulae with the 100-inch telescope on
Mount Wilson in California. The 100-incher, which was then new
nd was the biggest on earth at the time, had been able to resolve
tars in three nebulae, including the spectacular spiral Andromeda
nebula. A study of the periods of Cepheid variables in the nebulae
indicated that they were far more distant than any star in the
Milky Way galaxy – so distant that the nebulae to which they
belonged were clearly separate galaxies. Our galaxy is believed
to be some 100,000 light-years across. The galaxies studied by
Hubble were at distances of a million light-years or more.

Later, Hubble went on to study even more distant galaxies,
hundreds of them at distances of millions of light-years. He
concluded that the number of galaxies in the universe is about
as great as the number of stars in our galaxy. Astronomers,
accustomed to large numbers, casually say that there are
100 billion stars in our galaxy; in an expansive mood, some of
them increase the estimate to 200 billion or so. Since our Milky

Way is believed to be a sister to the spiral galaxies seen at gre distances, they are believed to have equal numbers of stars. The we are talking about perhaps 100 billion galaxies, each with som 100 billion stars. The intellectual odyssey that began with th earth at the centre of a small, easily mastered universe has led u to a universe of almost unimaginable extent in which we occup an inconsequential corner of an inconspicuous island.

Mankind's relatively new knowledge about the vastness o the universe is a key point in almost every aspect of SETI. Ar Unidentified Flying Objects visitors from another civilisation How many extraterrestrial civilisations might there be? What i the best strategy to follow as we try to communicate with such civilisations? The size of the universe and the distances both within our galaxy and to the galaxies beyond help define th answers. Our knowledge of the universe also helps answer per haps the most important question of all: how does life arise? And in fact, scientific ideas about the origins of life have evolved in step with scientific ideas about the size and structure of the universe. Our picture of the universe is the background against which theories of the origin of life are developed and tested.

The sheer size of the universe seems to say that life on earth i not unique. If the sun is one star of 100 billion in our galaxy, and there are 100 billion galaxies the size of ours, is it possible that life has arisen only once in this universe? Odds of 10,000 billion billion to one are not inviting. It is much more satisfying intellectually to say that the earth is just one of the cosmic crowd, a single example of many locations in the universe where life has de veloped.

But something more than an intellectually satisfying idea is needed. Once people said that Mars was the home of an advanced civilisation because that idea was intellectually satisfying. If we are to say that life has arisen many times in the universe, we need a common mechanism by which life can arise. More than that, if we are to say that life elsewhere in the universe is chemically like life on earth, it is necessary to show that the chemistry of earth's life forms is not unusual in the universe.

We must go back to the beginning and show how life came to our planet. Then we must show how life could come in the same way to other planets, circling other stars, in our galaxy and in others. To build a case for SETI, science must show how the dead chemicals of an original creation can come to life.

CHAPTER THREE

Chemistry and Life

> If a dirty undergarment is squeezed into the mouth of a vessel containing wheat, within a few days (say 21), a ferment drained from the garments and transformed by the smell of the grain, encrusts the wheat itself with its own skin and turns it into mice . . . And, what is more remarkable, the mice from corn and undergarments are neither weanlings nor premature but they jump out fully formed.

That recipe for creating life, given in the seventeenth century by the Flemish physician Jan Baptista van Helmont, has been more or less accepted for most of the history of mankind. The Rig-Veda the oldest Hindu scripture, says that life began from the primary elements. In the West, Anaximander described how the first animals originated from sea slime. Aristotle adopted the same concept in his *Metaphysics*. The idea gave birth to a phrase: spontaneous generation.

It made sense, even in the dawn of the modern scientific era. Anyone with reasonable curiosity could see mice arise from grain and maggots from wheat. Then someone with more than reasonable curiosity, a seventeenth-century Tuscan physician named Francesco Redi, put the matter to a test in 1668. Redi put out eight dishes of meat. Four were covered with cloth and four were not. As the meat rotted, maggots appeared in the four uncovered dishes but not in the four that were covered. The implication was clear: maggots arise in rotting meat because flies lay eggs there, not because of spontaneous generation. Case closed.

From 'Vital Force' to 'Warm Little Pond'

But the believers in spontaneous generation had a riposte. Not meat alone, but meat plus something indefinable in the air was needed for spontaneous generation, they said. The argument went on for a leisurely 200 years. It was brought to a conclusion when money entered the field. The French Academy offered a prize to anyone who could prove or disprove spontaneous

generation. Felix Pouchet, a French scientist, entered the lists. So did Louis Pasteur. Naturally, Pasteur won; universal geniuses have a way of doing that. Both he and Pouchet used the same technique: they exposed flasks containing broth to the air. Pouchet said his flasks, which started out sterile, invariably bred microbes. Pasteur said Pouchet got those results because he was sloppy enough to contaminate his flasks. Pasteur finally proved his point by making flasks with long, swanlike necks that allowed air to reach the broth within but trapped any microbes in the air. The broth remained clear of microbial life until the glass necks were broken. The victory went to Pasteur, who said in 1864: 'Never will the doctrine of spontaneous generation arise from this mortal blow.'

It was a barren victory. As was soon to become clear, spontaneous generation is an acceptable scientific concept. The only nineteenth-century alternative to spontaneous generation was to accept the existence of a 'vital force' from some supernatural power that makes living things essentially different from non-living things. Nineteenth-century chemists were busily undermining the foundation of the vital force concept by making organic molecules in their laboratories. The molecules of living things appeared so complex that it was thought that something special – the vital force – was needed to produce them. Now it became evident that they can be made by a diligent application of knowledge about the carbon atom. If Pasteur had killed spontaneous generation, he had left no acceptable concept of the origin of life in its place.

Svante Arrhenius, the great Swedish chemist, proposed an alternative theory at the beginning of the twentieth century: panspermia. Life on earth had begun because spores or other simple forms of life had drifted here from other planets, other stars. However, panspermia is subject to serious objections. One is the difficulty in surviving that any form of life, however simple, would encounter in the cold, radiation-drenched environment of outer space. But even if such a micro-organism could survive the interstellar trip, the panspermia concept just pushes the basic dilemma back one notch: how did life arise on that postulated other planet?

The answer was brewing in the writings of another genius of nineteenth-century science, Charles Darwin. He pictured an earth on which living organisms were evolving from simplicity to greater complexity under the influence of purely natural forces. How logical, then, to extend the concept of evolution

backwards in time and to picture living things evolving from non-living chemicals. In a now-celebrated letter to a friend, Joseph Dalton Hooker, Darwin wrote in 1871:

> It is often said that all the conditions for the first production of a living organism are now present, which could ever have been present. But if (and oh! what a big if!) we could conceive in some warm little pond, with all sorts of ammonia and phosphoric acid salts, light, heat, electricity, etc, present, that a proteine [sic] compound was chemically formed ready to undergo still more complex changes, at the present day such matter would be instantly devoured or absorbed, which would not have been the case before living creatures were formed.

It was a fascinating, premature idea – premature because nineteenth-century scientific thinking simply could not fit it in. Darwin himself had said as much a few years earlier, in a letter to Hooker: 'It is mere rubbish, thinking at present of the origin of life. One might as well think of the origin of matter.'

The twentieth century was to think of the origin of both. The pioneer appears to have been a Russian biochemist, Alexander Ivanovich Oparin, who as early as 1924 wrote that 'there is no fundamental difference between a living organism and lifeless matter. The complex combination of manifestations and properties so characteristic of life must have arisen in the process of the evolution of matter.' Oparin's theory, in which he described 'a new colloidal-chemical order' arising 'as a result of growth and increased complexity of the molecules' was not published in English until 1938. Well before then, J. B. S. Haldane of Cambridge University, one of the great scientific spirits of the twentieth century, had come up with essentially the same idea.

Both Haldane and Oparin were able to use knowledge about the chemical composition of the universe that had only recently become available. Studying the stars and interstellar gas, astronomers found that the universe consists mostly of hydrogen. A study of the huge outer planets of the solar system, such as Jupiter, indicated the presence of hydrogen-containing compounds such as ammonia and methane. The oxygen that is so plentiful in the earth's atmosphere (which is roughly one-fifth oxygen) was notably lacking. So both Oparin and Haldane started with an earth whose early atmosphere was rich in both compounds of hydrogen and compounds of carbon, mainly carbon dioxide, and that was bathed in ultraviolet light from the

sun. The action of ultra-violet light on the early atmosphere produced a vast number of carbohydrates (which, as the name implies, consist of carbon, hydrogen, and oxygen), which accumulated in the primitive oceans until they formed what Haldane called 'a hot dilute soup'. It is a picture essentially identical to Darwin's 'warm little pond'.

The difference between Darwin's off-hand speculation and the appreciably more detailed theories of Oparin and Haldane was the increase in information about the nature of the chemistry of life and about the nature of the universe. The same sort of scenario was to be played over the following decades: an inspired, informed hypothesis followed by an advance in scientific knowledge which permitted confirmation of the theory.

For example, in 1947, J. D. Bernal, another of the great names in British science at that time, delivered a scientific paper, 'The Physical Basis of Life', before the British Physical Society. Bernal took Haldane's 'hot dilute soup' one step further. The primeval 'soup' was too dilute for the concentrations that would enable the small, primitive molecules to form the large macro-molecules needed for reproduction, the most critical function of living organisms. Such macro-molecules did not form by themselves in the open sea, Bernal said. He hypothesised that deposits of clay along the seashore helped the formation of macro-molecules: the smaller molecules became attached to the surface of the clay and then joined together. Exactly thirty years later, two scientists working at the National Aeronautics and Space Administration's Ames Research Center in California performed an experiment that supported Bernal's hypothesis. The scientists, James Lawless and Nissim Levi, found that a specific kind of nickel-bearing clay attracts the sub-units out of which proteins are made. Chains of those sub-units form more or less spontaneously on such clay, they said.

The Mechanism of Life

Between Bernal's theorising and the American experiment came one of the greatest achievements of biological science: the discovery of the basic mechanism by which living organisms function and reproduce. Volumes have been written about every step in the road towards the discovery. A summary must suffice here.

Proteins do the work of the cells that make up living organisms. Proteins are made up of sub-units called amino acids. Twenty

different amino acids are found in the proteins of organisms on earth, in the same way that twenty-six letters are found in the English language. We can form words of any length by stringing letters together, and proteins of any length can be formed by stringing amino acids together. Our hair is protein, our skin is protein, and, more important, the molecules that carry out the basic functions by which living cells eat, excrete and do almost everything else are proteins. To oversimplify grossly, a protein is made of hydrogen, carbon, and phosphorus, with a few other elements, notably sulphur.

Proteins are so important that it was widely believed until the middle of the twentieth century that they are also responsible for storing the genetic information that allows traits to be passed on from one generation to another. To everyone's surprise, that theory was not true. Instead, the genetic material proved to be macro-molecules called nucleic acids. A nucleic acid consists of subunits called nucleotides. There are two kinds of nucleic acid: ribonucleic acid, or RNA, so called because its nucleotides contain a sugar called ribose, and deoxyribonucleic acid, or DNA, so called because its nucleotides contain a sugar like ribose, but with one less oxygen atom. RNA is the genetic material for some primitive organisms, but DNA is the genetic material for all reasonably complex organisms, up to and including mankind.

'Genetic material' means this: the DNA molecule consists of two interlocking chains, each containing many thousands or millions of nucleotides. The chains can divide and reproduce themselves, so that each succeeding generation gets an accurate copy of the preceding generation's genetic material. The chains also govern the production of proteins. There are four different nucleotides in the DNA molecule. That is enough to carry the code for the twenty proteins, in the same way that just two symbols, a dot and a dash, can carry the information to pick out any one of the twenty-six letters in the Morse Code. A group of three nucleotides codes for a single amino acid. To make a protein, the DNA message is used to produce RNA molecules, which put together the amino acids in the required sequence. Very little of this was known twenty years ago. Today, it is taught by rote to bored sixth formers.

With this sort of knowledge available, it is possible to carry out an experiment to test the theory of spontaneous generation in a much more sophisticated way than Pasteur did. But the theory that is being tested is far different from that tested by Pasteur. He looked for the spontaneous generation of microbes, which are

very complex organisms on the molecular scale. Spontaneous generation today looks for the formation of relatively simple molecules of nucleic acid and protein, under the conditions assumed to have existed at the earliest stage of the earth's formation.

Probably the most influential experiment of this sort was performed in 1953 by Stanley Miller, a student working under Harold Urey, the Nobel laureate in chemistry, at the University of Chicago. Miller created the atmosphere assumed to have existed on the primitive earth – methane, ammonia, hydrogen, and water – in a laboratory flask. Electrodes were placed in the flask, and periodic sparks were sent through them to mimic ultraviolet radiation and lightning. The flask was heated until the water boiled, and the water was allowed to circulate through a closed loop of tubes. Soon the water took on a pink appearance. After a few days, it was deep red. Subjected to chemical analysis, the water was found to contain a number of organic compounds. Significantly, four of the amino acids that are commonly found in protein were among them.

The Urey-Miller experiment was influential not so much because it was the first – a few other experiments had achieved less advanced results with the same kind of apparatus – but because it showed in convincing fashion that it was possible to produce large quantities of organic compounds starting from what amounted to nothing more than air and water. Much of the work done since then amounts to variations on the theme. The Urey-Miller apparatus is simple enough to be set up in any well-equipped laboratory, and many other scientists were soon at work. For example, Philip H. Abelson, working at the Carnegie Institute in Washington, showed that organic molecules could be produced using a variety of mixtures of gases, as long as oxygen was not the predominant gas. When free hydrogen was present and oxygen was not, the 'hot dilute soup' of organic molecules resulted. In more technical terms, the artificial model of the primeval atmosphere had to be 'reducing', as opposed to 'oxidising'. The earth's atmosphere is now oxidising – that is, it contains a large amount of oxygen which combines freely with (oxidises) almost anything it touches. A reducing atmosphere contains little or no oxygen. It does contain such compounds as methane and ammonia, as well as hydrogen, which are known chemically as reducing agents.

Over and over in the past decades, scientists have worked with such a model of a reducing atmosphere to try to produce the

basic chemicals of life, with great success. In 1963 Cyril Ponnamperuma and Melvin Calvin of the University of California at Berkeley used an electron beam from a particle accelerator to provide energy to such an atmosphere. German and Soviet scientists have used ultraviolet light. A few experiments have tried to mimic the effects of the shock wave that would be created by a meteorite plunging through the earth's atmosphere. Sometimes different starting materials are used: for example, ammonium formate and hydrogen cyanide, both of which are assumed to have been relatively plentiful on the primitive earth. In the words of Ponnamperuma, 'All these different types of experimentation and simulation of pre-biological conditions have produced many of the building blocks of life, such as amino acids, purines, pyrimidines, carbohydrates, etc.' (Pyrimidines and purines are essential parts of nucleotides.)

However, it could be (and has been) said that these experiments really prove nothing, because they are all aimed at hitting a known target. It can be argued that if you know what kind of molecules you want to produce, you can juggle the elements of the experiment until they produce the expected results.

There are a number of answers to this argument. The most convincing comes from a study of molecules in space. We are used to thinking of the regions between stars as empty, but clouds of dust and gas are out there. The nature of the molecules in these interstellar clouds can be determined in several ways, all of them based on the emission or absorption of different kinds of energy. Each variety of molecule emits or absorbs specific wavelengths of energy. An emission or absorption spectrum identifies a molecule as surely as a fingerprint identifies a human being. For more than four decades, astronomers have been searching for these fingerprints in space. The first interstellar molecule to be discovered was a two-atom molecule of carbon and nitrogen, called cyanogen, whose chemical symbol is CN, which was found in 1937. Three years later, a two-atom molecule of carbon and hydrogen (CH), methylidyne, was discovered. Today, more than thirty interstellar compounds have been found, from simple two-atom molecules to compounds as complex as ethyl alcohol, the same kind found in martinis.

So we know that some simple molecules related to life are being produced in space. But we know more than that, from the

most direct evidence: many complex organic chemicals are being produced in space and are arriving on earth. Their vehicles are meteorites, specifically a kind of meteorite called a carbonaceous chondrite. The organic chemicals that are found in abundance in these meteorites are astoundingly similar to those found in living organisms on earth. The resemblance is so striking that there was a brief time in the 1960s when at least some scientists believed that carbonaceous chrondites were bringing living matter to the earth.

Meteorites have been raining down on earth for as long as can be imagined. Sometime more than a century ago, they began to be collected, and to be named after their landing sites. There is the Orgueil meteorite, which landed in France in 1864, the Murray, which fell in Kentucky in 1950, the Murchison, which fell in Australia in 1969, and so on.

That carbonaceous chondrites contain organic matter has been known for a long time. In 1834, Jons Jakob Berzelius, the celebrated Swedish chemist, reported that he had extracted organic compounds from the Alais meteorite, which fell on France in 1806. Other nineteenth-century scientists made similar studies of other meteorites, with essentially the same results. But the real fun started in the early 1960s, when some scientists began subjecting samples of carbonaceous chondrites to modern methods of analysis. Some of the scientists said they extracted molecules whose existence could be explained only by the action of living things. Other scientists said they had been able to extract real living bacteria from the meteorites.

It made juicy reading, and it started a violent debate. After the arguments and the counter-arguments settled down – it took some time, because nothing can be quite as bitter as a polite scientific controversy – a consensus was reached, based on analyses made largely by Ponnamperuma and other scientists at the Ames Research Center, a NASA facility in California. Those analyses were able to explain away a good part of the earlier reports as the result of contamination of the meteorites with terrestrial material. The contamination problem was especially severe for the Orgueil meteorite, which had been on earth for over a century.

But the clinching evidence against a biological origin for the meteorite compounds came from one of the most curious aspects of life on earth – the lopsidedness of amino acids.

Actually, 'lopsided' is the wrong word. Amino acids can be right-handed or left-handed. Your right hand and your left

hand may seem at first to be identical. But they are not, because they cannot be superimposed on each other. In the same way, your mirror image is not identical to you. And in just the same way, a right-handed amino acid is not identical to a left-handed amino acid.

The amino acids in living organisms on earth are left-handed. No one knows why this is so. The assumption is that life started just once on earth, and that it got off to a left-handed start by pure chance. If this is so – and it is pure hypothesis – we humans and every other living thing on earth can trace our ancestry back to one chance combination in a primeval organic soup.

The amino acids in meteorites are neither entirely right-handed nor entirely left-handed. The meteorites contain equal amounts of right-handed and left-handed amino acids. Ponnamperuma's team first examined the Murchison meteorite, later the Murray and the Orgueil (for the latter, they used a technique which enabled them to distinguish between the amino acids that were present originally and those that were present because of contamination). The results were the same. Not only were the amino acids equally divided between right-handed and left-handed molecules, but some of the amino acids in the meteorites are not found in terrestrial proteins. Ponnamperuma later wrote: 'We are therefore led to believe that the amino acids in the Murchison meteorite were produced by an abiotic [non-living] extra-terrestrial process.'

Ponnamperuma added a significant comment: 'The analysis of this meteorite thus provides us with, perhaps, the first conclusive evidence for the process of chemical evolution occurring elsewhere in the universe.' The important word here is 'chemical', because it indicates the revival, in a more sophisticated form, of an old idea: Arrhenius's idea of panspermia.

Panspermia has been revived in the same way that spontaneous generation has been revived: in a greatly modified version that fits the facts known to current science. No one conceives of a fully formed life-form arriving by chance from a distant planet, just as no one thinks of living organisms such as maggots arising from river slime. But it is thought possible that many of the essential chemicals for terrestrial life evolved to a large extent in outer space, the 'chemical evolution' of which Ponnamperuma spoke. The existence of some of the chemical precursors of life in interstellar space is a starting point for that belief. The presence of organic compounds in meteorites is another indicator. In 1971 Ponnamperuma pointed out that his research team had found the

same eighteen amino acids and two pyrimidines, which are essential to nucleotides, in both the Murchison and Murray meteorites. 'The findings of this identical complex pattern of amino acids and pyrimidines in two meteorites could mean that this is a basic phase in the chemical process leading to life. This basic sequence in the formation of organic molecules could be determined by the inherent chemical characteristics of the material of our universe,' he wrote.

The Seeds of Life

Fred Hoyle, a British astronomer who specialises in mind-stretching ideas that sometimes appear to outrage common sense but always stimulate thought, has gone a step further. In collaboration with N. C. Wickramasinghe of University College in Cardiff, Hoyle has proposed that actual living organisms can evolve in interstellar clouds. Given the presence of the molecules known to exist in interstellar clouds as well as grains of dust, Hoyle and Wickramasinghe envision a complex organic chemistry, driven by the radiation that floods outer space, taking place on the surface of the dust grains. The end result, they say, could be a simple living organism, such as a spore, which would be protected from radiation damage by clumps of dust and would feed on the molecules within the cloud.

If that idea is too hard to swallow, how about the presence of tar in outer space? Tar consists of long chains of carbon atoms, with hydrogen atoms attached. In recent years, astronomers have detected a series of interstellar molecules consisting of carbon chains, with some hydrogen and nitrogen. The general chemical formula for such molecules is HC_nN, where H is hydrogen, N is nitrogen, C is carbon and the subscript $_n$ can stand for any number of carbon atoms. Chains of up to seven carbon atoms had been detected by 1977, and a search for more complex molecules was going on. Looking at the spectrum of radiation absorbed by interstellar dust clouds, Hoyle and Wickramasinghe found 'an indication here of a fairly complex, radiation-resistant pre-biological polymer associated with interstellar grains . . . Such pre-biological polymers, processed in the interstellar medium, could have played a crucial part in the evolution of terrestrial life.'

There are two important implications of chemical evolution in outer space. One is the indicaton that life elsewhere in the universe could be chemically quite similar to life on earth – that is,

built around carbon compounds, and relying heavily on the proteins and nucleic acids that are essential to terrestrial life. Even though Carl Sagan, one of the founders and leaders of SETI, likes to warn against 'carbon chauvinism', the conclusion that life elsewhere in the universe is carbon-based is hard to avoid.

Long, complex molecules are necessary for life. Carbon has a unique ability to form such molecules. A carbon atom can form bonds with four other atoms. Because the carbon-carbon bond is unusually strong, carbon atoms can form very long chains that are exceptionally stable at ordinary temperatures. No other element can form such chains. For example, silicon also forms four bonds, but the silicon-silicon bond is not as strong as the carbon-carbon bond, so silicon does not form long, stable chains. Even though silicon is much more abundant on earth than carbon, there is not a trace of silicon-based life on earth. Most of the silicon on our planet has combined with oxygen to form silicon dioxide, the basic ingredient of sand. At our present state of knowledge, a long strech of the imagination is required to envision anything but carbon-based life forms.

The second implication of the studies of interstellar compounds is that life-forms on other planets are not only carbon-based but that such life-forms could easily be widespread in the universe. Scientists see that the basic building blocks of life on earth form spontaneously in outer space. They see that these building blocks arrive in appreciable quantities on earth. From laboratory experiments, they have worked out a number of alternative pathways by which these building blocks can be put together, in quite ordinary chemical reactions, to form more complex organic compounds. Through a combination of theory and experiment, they have glimpses of the ways in which these organic compounds can combine to produce the self-replicating aggregates of molecules that are the first organisms we can describe as living. And they have a convincing picture of the way in which these first crude organisms could evolve into more efficient and more complex living things.

The picture starts with Haldane's 'hot, dilute soup', probably fed by organic material from meteorites. The early earth is a hot planet, whose atmosphere is rich in hydrogen and its compounds. Ultra-violet radiation from the sun penetrates through to the earth's surface easily. Lightning flashes in the sky. With a plentiful supply of raw materials and energy, the building blocks of life, amino acids and nucleotides, are formed out of ammonia,

methane and water.

A mechanism is needed to put these building blocks together so as to form macromolecules. Several mechanisms have been mentioned. Leslie Orgel, working at the Salk Institute in La Jolla, California, believes that a molecule called imidazole could have done the job. Imidazole can serve as a catalyst, increasing the rate at which a chemical reaction occurs but not being consumed by that reaction. Orgel's calculations indicate that imidazole could have been formed in the early earth's hot soup by a variety of actions. Imidazole could have put together short chains of amino acids or nucleotides in the absence of water – on a beach, for example.

Imidazole catalysis is not the only possibility. At the Ames Research Center, a research team headed by James Lawless and Nissim Levi, a visiting Israeli, reported in 1977 on the efficiency of ordinary clay as a catalyst.

The Ames researchers found that all metal-containing clays attract amino acids (by definition, all clays contain metals). They also found that one kind of clay, that which contains nickel, attracts exactly those twenty amino acids found in living things on earth. Seven other clays tested at Ames did not have this specific attraction, but they had a quality of equal importance: they destroy amino acids which do not form proteins.

Thus clays could act in two ways to produce the macromolecules of which we are made. Most clays destroy a large number of amino acids, while one specific kind of clay catalyses the formation of chains of the other amino acids. In a test that simulated the action of the tides – drying an amino acid-clay solution, warming it, wetting it, drying it, and so on for a number of cycles – chains of as many as eight amino acids were formed. Given long periods of time, presumably even longer chains would form.

The Ames researchers found much the same picture in their work with nucleotides and clays. One clay which contains zinc concentrated the nucleotides that make up DNA. Significantly, zinc is known to play an important role in an enzyme called DNA polymerase, which is found in living cells and which links nucleotides to form large DNA molecules.

Those are two possible mechanisms by which macromolecules of nucleic acid and protein could form. Many other mechanisms are possible. The important point is that large, complex molecules can form from simple molecules of the kind that are believed to have been plentiful on the early earth.

Over millions of years, many billions of such macro-molecules must have formed on the early earth. Most of them broke down fairly quickly, but the supply was constantly replenished. At last came one of the most important events in the history of the earth. A single molecule somehow managed to put together simpler molecules from its surroundings to produce a copy of itself. The ability to reproduce would give a molecule an evolutionary advantage over all non-reproducing molecules. Soon, copies of that reproducing molecule would begin to become predominant. It is even possible that a single molecule and its descendants filled all the waters of the earth.

Picture many billion descendants of that original molecule being reproduced over many millions of years. The reproduction was not always perfect, especially in an atmosphere in which radiation interfered with chemical processes. New types of molecules were produced by accident. Some of those accidents were more efficient at reproducing than others. The more efficient molecules came to predominate.

As the variety of molecules increased, accidental encounters occurred often. Some molecules that bumped together stuck to each other. The combination was more efficient than two single molecules. Larger and larger aggregates of molecules formed in this way. Gradually, an assemblage resembling a living cell took form. By this time, the supply of food – other molecules – was diminishing because competition was increasing. The next big step in evolution occurred: a primitive assemblage began to make its own food by tapping solar energy through the process called photosynthesis. It was a primitive, inefficient form of photosynthesis, using hydrogen sulphide and giving off sulphate ions, but it worked.

By this time, there may well have been a variety of fairly complex life-forms on earth – complex by comparison with the first macromolecules, that is; they were quite primitive by today's standards. It is believed that the kind of living cell found in higher organisms formed when some primitive life-forms captured and enslaved others. Some of the components of a living cell today still bear the vestiges of a once-independent existence. Just as chain stores swallow mom-and-pop grocery stores, so an enterprising early cell gave itself an evolutionary advantage by swallowing a small but efficient competing cell that provided it with a new capability.

It was well along in the earth's history when another pivotal development – the invention of oxygen respiration – occurred.

Anaerobic respiration, using hydrogen compounds, is an inefficient form of metabolism. The first cells that learned how to use water and carbon dioxide to make sugars, releasing oxygen in the process, not only became more efficient but also changed the character of the planet forever. As free oxygen in the atmosphere increased, some of it drifted upwards to form an ozone layer that blocked out most of the sun's ultra-violet radiation. (Ozone, a three-atom molecule of oxygen, is formed by ultraviolet radiation and absorbs it effectively.) Free from the peril of ultraviolet radiation, life-forms on earth became more stable. Evolution went on briskly. Here we are.

The rise of more complex life-forms took place over three billions of years. Here we are concerned with the beginnings of it all. From all the laboratory work and astronomical observations, it appears that the capacity for life is not rare, but is woven into the fabric of the universe. The seeds of life – our kind of life, carbon-based and using water – are scattered throughout the universe, waiting only for the right conditions to start germinating. And through their studies of the universe, astronomers also have a reasonably good idea of how often the right conditions occur.

CHAPTER FOUR

The Universe and Us

The basic tool of SETI is the radio telescope. While speculations about life on other planets are centuries old, the modern era in which we can talk realistically about communicating with civilisations elsewhere in the galaxy was born only when the radio telescope came of age. More than that: radio telescopy has also helped to give us a picture of the universe that makes possible a reasonable assessment of mankind's chances of finding and communicating with other intelligent life. It was the radio telescope that enabled astronomers to develop their current model of the age, structure, and evolution of the universe. To the old image of the astronomer peering at stars through a huge light-gathering telescope must be added the picture of astronomers reading the jagged graphs that represent the data gathered by bowl-shaped, metallic radio telescopes.

Light and radio waves are two kinds of the same thing: electromagnetic radiation. So are X-rays and gamma rays and ultraviolet radiation and infra-red radiation. We can measure electromagnetic radiation either by wavelength or by cycles per second. The two measures are directly related: the longer the wavelength, the fewer the cycles per second, and vice versa. That is because all electromagnetic radiation travels at the same speed, which is often called 'the speed of light'. (That speed is 186,292 miles per second. In the metric system, the speed of light and of all other electromagnetic radiation is a rounder number, roughly 300,000 kilometres per second.)

A wave of visible light is about one hundred-thousandth of an inch long. A radio wave is about half a mile long. You can learn about the number of cycles per second of radio waves by consulting the dial of your radio. 'Cycles per second' now are called Hertz, to honour a pioneering scientist. The AM band on your radio is measured in kilohertz, or thousands of cycles per second, while the FM band is measured in megahertz, or millions of cycles per second. If you look at the sky at night, the visible light from stars has a frequency of about ten million billion cycles per second. The distance to those stars is measured in light-years, the distance that light travels in one year – about six trillion miles. Distances of thousands, millions or even billions of light-years are common in astronomy.

Telescopy

Since mankind has always looked at visible light from the stars, light telescopy developed early in the modern scientific era. Radio telescopes are developments of the past few decades, and they started through an accidental observation. Karl Jansky, an engineer with Bell Telephone Laboratories, built an antenna in New Jersey in 1931 to study the static that interfered with long-distance telephone calls. He found one kind of radio noise whose source seemed to move with the sun. With some help from an astronomer friend, Jansky found that the radio source seemed to lie towards the centre of our galaxy. Soon it became apparent that the radio signals were in fact coming from the centre of the galaxy. In addition to visible light, the stars in the galaxy were also emitting radio waves. It was a revolutionary discovery, but when Jansky reported it in 1932, astronomers were mostly indifferent. One amateur named Grote Reber built his own antenna near Chicago and found that the whole Milky Way is a source of

radio signals, but professional astronomers did nothing to follow up Janksy's work. Science moved at a more leisurely pace in those days than it does in our era. Now an exciting astronomical observation will be followed up eagerly by many different research teams as soon as it is reported. But Reber did not publish his results until 1940, almost eight years after Jansky's first publication. By then, World War II was upon us, and most purely scientific work was suspended for the duration.

However, the war eventually gave great impetus to scientific research. It was the first war in which scientists were recruited methodically and in large numbers to work on military projects. Anything of potential military use was assured of financial backing, and if the military use was valuable, an almost endless supply of money was available. The atomic bomb was the prime example of this marriage of the military and science. Electronics came close behind, if only because radar had changed the course of the war.

When the war ended, the Cold War began, and the wedding of science and war became even more intimate. All sorts of electronics research boomed ahead, helped greatly by liberal military funding. In the general climate of post-war affluence, even basic research benefitted. The large bowl-shaped antennas needed to collect radio signals from the cosmos appeared in every scientifically advanced nation.

The dishes that collect radio signals must be big because radio waves are so long. Big is beautiful in radio telescopy, because bigness improves the quality of reception. There are many movable radio telescopes with dishes that are several hundred feet in diameter, but there is a limit to the size of any single movable antenna. If it is too big, wind and weather will play havoc with it.

There are several ways to get around the size limitation. One way is to build an immovable antenna. The largest single antenna on earth is in Arecibo, Puerto Rico, where a 1000-foot dish has been built in a natural bowl-shaped geological formation. The builders have done little more than smooth out the circular valley in the green hills of the island, and then lay down acre on acre of precisely engineered metal to gather the radio signals. If it were nothing else, the Arecibo radio telescope would certainly be one of the most beautiful scientific facilities on earth.

The Arecibo observatory has one major disadvantage. The dish cannot be pointed at more than a limited portion of the sky. But its great size gives it many advantages over smaller radio

telescopes. Arecibo also serves as a useful yardstick for SETI. Any number of papers include calculations based on the postulated existence of a radio telescope the size of the Arecibo dish elsewhere in the galaxy.

Radio telescopy has helped settle many major debates about the universe that raged among astronomers a few decades ago. In particular, one discovery by a radio telescope has led to a consensus about the origin and evolution of the universe

If we opened a book on astronomy and cosmology about fifteen years ago, we would have found explanations of two conflicting theories about the nature of the universe: a big-bang theory and the steady-state theory. Both of them were attempts to explain the observation that the universe is expanding.

'Big Bang' vs 'Steady State'

Edwin Hubble discovered the expansion of the universe in the 1920s, using a light telescope. He found that the light emitted by distant galaxies is not the wavelength that it should be. The light is shifted towards the red – or longer wavelength – end of the visible spectrum, because the galaxies are moving away from us. We get the same effect on earth when we hear an automobile horn appear to wail as the auto speeds away; the sound waves of the horn are stretched out because the auto is moving away. In the universe, the 'red shift' of a given galaxy is directly related to its distance from earth: greater distance means a larger red shift, and hence a greater rate of speed.

Picture dots on a balloon. If the balloon is inflated, the dots will move apart. From the vantage point of any single dot, it will appear that all the others are flying away, and that the most distant dots are moving away the fastest. So it is with the universe, except that the dots are galaxies.

One explanation of the expanding universe took a motion picture of the speeding galaxies, ran the film backwards and arrived at a moment when all the mass in the universe was in one 'superatom'. Some unexplained explosion – a 'big bang' – sent the matter streaming out, this theory said. An alternative theory said that the universe has always looked like this. The steady state of the universe is maintained by the constant creation of new matter, according to this theory.

The big-bang theory is accepted now, because radio astronomers can detect a faint background noise that pervades the entire universe. This noise is the remnant of the big bang, the

explosion of the superatom that started the expansion of the universe some fifteen to twenty billion years ago.

Starting with the big bang and using a combination of theory and observation, astronomers have developed a picture of the evolution of the universe. Many details are uncertain, but the picture is reasonably compete, from the largest scale – the origin and history of galaxies – to the smallest. Among the smallest details in this cosmological picture is the formation of planets such as the earth. Another detail is the origin of life on such planets. On the cosmological scale, a planet such as the earth is no more than a pebble on a very large beach, and life on the planet is a thin film of scum on the pebble. But the theory that is accepted by many astronomers makes both the formation of planets and the existence of life on them an integral part of the history of the universe.

After the big bang occurred, the universe consisted mostly of hydrogen, with some helium thrown in. Hydrogen is the simplest element; its nucleus consists of a single particle called a proton. The helium nucleus consists of two protons and two neutrons.

As this gas streamed out from the big bang, eddies formed. The expansion of the universe was constant, but matter was not distributed evenly through space. Instead, it tended to clump together. On the largest scale, those clumps are the galaxies. They are truly island universes. Everywhere that astronomers look in the universe, they find galaxies floating in the sea of space. Galaxies come in a variety of shapes, from globular clusters, which are spherical, to flat discs of billions of stars, with spiral arms as if they were pinwheels spinning in space. The Milky Way galaxy is such a disc.

Galaxies are spinning. They must, or they would collapse into a single mass as a result of the gravitational attraction of the matter they contain. This rotation is important for the formation of stars. Just as huge eddies lead to the formation of galaxies, eddies on a smaller scale lead to the formation of stars within galaxies. The two processes are essentially identical, except for scale. Just as galaxies always form in clusters, stars always form in clusters.

Envision an eddy of gas and dust, a cloud just a few degrees above absolute zero. The cloud begins to collapse because of the gravitational attraction of its matter. Gravitational energy produces heat and radiation. As the collapse continues and the density of the cloud increases, more and more of this energy is trapped within the cloud. Its temperature rises. At one time or another, the amount of pressure created by the radiation almost

equals the gravitational attraction. The cloud is what we call a protostar. It is about the size of our solar system and is collapsing steadily. Bart Bok of the University of Arizona has discovered small, dark bodies that have all the characteristics of protostars. These Bok bodies are believed to be stars in the process of formation. Other astronomers have detected what seem to be stars in the earliest stages of their birth.

Both gravitational collapse and temperature rise continue until the centre of the cloud becomes so hot and dense that the hydrogen nuclei are squeezed together. Very great pressure and high temperatures are needed for the fusion of hydrogen nuclei, but it does occur in the interior of stars. The fusion of four hydrogen nuclei forms one helium nucleus and releases a great deal of energy. On earth, we are familiar with fusion in hydrogen bombs, which have given mankind the ability to destroy itself. If we do wipe out life on earth by using hydrogen bombs, we deserve no credit for originality. We have simply borrowed from the stars.

Stars Are Not Created Equal

Stars are not created equal. Some are brighter than others. Some burn low, with a dim, red glow, while others burn with a white intensity. For something close to a century, astronomers have been classifying stars by their brightness and temperature. One of the methods of classification uses letters, in a quite illogical sequence. Starting with the hottest stars and moving towards the cooler, the types are listed as:

O, B, A, F, G, K, M,

which can be remembered by the classic mnemonic, 'Oh, be a fine girl, kiss me.'

It is possible to plot a graph of stars which relates their temperature and their brightness. Such a graph is called a Hertzsprung-Russell diagram, after the two astronomers who developed it. If brightness is graphed from top to bottom and temperature is graphed from left to right, most stars fall in a broad, wavy band that runs from the upper left to the lower right. This band is called the 'main sequence'. Our sun is pretty close to the centre of it.

The sun has been on the main sequence for five billion years, and will be on it for another five billion years. The sun is a G star, pretty much a stellar mediocrity. There are many stars like the

sun on the main sequence, a fact that is very important to SETI. But the sun is also a particular kind of main-sequence star, which is also important in the matter of life in the universe – specifically in the matter of life in the solar system.

The mass of a star determines both its place and the time of its stay on the main sequence. Stars with low mass are cooler and thus less bright; they are towards the lower part of the main sequence, and they will spend a long time there. Because the temperatures and pressures inside them are relatively low (by stellar standards), these small stars will burn their hydrogen fuel at a moderate rate for a long time. At the upper end of the main sequence are the most massive, hottest, brightest stars. They will be gone in a twinkling – a million years or so. There are size limits at both ends of the main sequence: nothing with a mass less than about one-twelfth that of the sun can achieve fusion, and stars with masses 100 times or more that of the sun probably do not exist.

Stars die, often explosively. Stellar death is a fascinating and complex process, but we are interested in only a few major points. Death occurs because the star uses up its fuel. Hydrogen can be fused into helium for just so long, until the hydrogen is almost exhausted. Helium nuclei can be fused to form heavier nuclei, and those nuclei can be fused to form even heavier nuclei; but there comes a time when the energy output of the star cannot balance the gravitational pull of its matter. If the star is massive, it explodes, sending a good fraction of its material out into space.

That material joins the clouds of interstellar gas and dust, and some of it eventually is incorporated into new stars. Unlike the stars we have described until now, the new stars start off with more than just hydrogen and helium. They contain heavier elements – carbon, oxygen, nitrogen, sulphur, and phosphorus, among others – formed in fusion reactions in the old stars.

Stars that contain these heavier elements are called second-generation stars. They get the heavier elements from first-generation stars, which contain only hydrogen and helium. The sun is a second-generation star. When the sun set up shop some five billion years ago, the universe had been in existence at least two, and perhaps as much as three times longer than that. Time is an element that cannot be forgotten in SETI, and we will return to it.

Spin is important to stars, too. As an eddying cloud of gas and dust begins the contraction that leads to formation of a star, it is

spinning. The more the cloud contracts, the faster it spins. Before long, the cloud looks something like a football: a dense central bulge, which will become the star, surrounded by a halo of dust and gas, which will become planets.

Dwell for a moment on that last sentence. It assumes quite matter-of-factly that the formation of planets is a routine affair in the history of a star. Yet less than half a century ago, Sir James Jeans, one of the great astronomers of the century, proposed a theory that would have made the creation of our solar system an unusual – perhaps unique – event, the product of a near-collision between our star and another. It was a theory that many scientists could accept when we lived in a smaller, more manageable universe where the earth could be regarded as something out of the ordinary. Today, when we know that the earth is just a dust mote in space, we have a theory in which the earth and the entire solar system are all too ordinary.

Back to the spinning protostar. The central bulge is surrounded by a disc of dust and gas, the solar nebula. Grains of dust in the nebula begin to stick together, forming larger particles. As fusion reactions switch on and the sun begins to radiate heat, lighter gas is driven towards the edge of the disc, while heavier material stays towards the centre. Close to the sun, the dust particles accumulate to form pebbles, rocks, boulders – eventually planetesimals – small planets – that pull in more matter until full-sized planets form. Out away from the sun, the planets that form are both bigger and lighter, consisting mostly of the gases such as hydrogen and helium that were in the solar nebula. In our solar system, the four inner planets – Mercury, Venus, Earth and Mars – are rocky, while the planets farther from the sun – Jupiter, Saturn, Uranus and Neptune – are gaseous. (Pluto, the ninth and outermost planet, is something of a mystery.) Meteorites are believed to have formed at the same time as the planets, and thus they give us a sample of the earliest material of the solar system.

There is reason to believe that this distribution of matter is typical of other planetary systems even though there is no iron-clad evidence that other solar systems exist. Stephen Dole, an American astronomer, has run computer simulations of the formation of planetary systems from a solar nebula. Starting with a typical solar nebula, Dole's computer programme prints out a series of planetary systems remarkably like ours – rocky planets close to the sun, gaseous planets farther out. The sizes and distributions of the planets vary somewhat, but the resemblance between the computer-generated planetary systems and the solar

system is unmistakable.

Dole's computer programme even generated situations in which one of the bodies orbiting the protostar was large enough to become a star itself. Binary (two-star) systems are common; in fact, most of the stars we can see from earth are in multiple-star systems. It appears that the difference between a star and a planet is only one of mass. If Jupiter, the largest planet in the solar system, were about eighty times more massive, it would be large enough to generate fusion reactions, and the sun would be part of a binary system.

Direct evidence for the existence of planets around other stars is controversial, but spin gives indirect evidence that planetary systems are common. The rate of rotation of a star should be in direct relationship to its mass: the more massive the star, the faster it should spin. This relationship holds, but only up to a point – a most interesting point for SETI. Hot, bright stars – the more massive ones – do spin rapidly. They can take only a few hours for a complete rotation. By this standard, our sun should complete a rotation in less than a day. In fact, the sun revolves only once every twenty-five days. And the sun is not unusual. Stars that are about the size of the sun spin much more slowly than they should. Astronomers have found an abrupt change in rotational speed in stars whose mass is about that of the sun. Something has to slow the rotation of these stars, and planetary systems seem to be the logical explanation.

But there is a pesky problem to which astronomers did not have a solution until recently: how is spin (or, to use the formal term, angular momentum) transferred from a star to its planets? One reason why Jeans and other astronomers postulated a collision between stars to explain the existence of the planets was the lack of a theory to explain why the planets had a much greater share of the angular momentum of the solar system than they should. Today it is believed that the angular momentum was transferred from the protostar to the planets by means of an intense magnetic field. According to this theory, the protosun created a magnetic field in the gas halo that surrounds it, and the effects of this magnetic field transferred angular momentum from the protosun to the planets-to-be.

One of the most significant points of this theory for SETI is that it paints an extremely optimistic picture of intelligent life in the universe. Not only on theoretical grounds but also from observation, we know that life emerged on earth very early in the history of the planet. On the principle of mediocrity, we can

assume that life is an early arrival on earthlike planets in other solar systems. However, again from the principle of mediocrity, we must assume that *intelligent* life makes a relatively late appearance. On earth, the interval between the production of the first life-forms and the presence of intelligent life is much more than three billion years.

Therefore, a giant star that burns out its fusion fuel in a few hundred million years, or even in a billion years, is not likely to have a planetary system that could harbour intelligent life. Even if an extremely massive star does have earthlike planets, there simply will not be enough time for intelligent life to evolve on those planets before the star dies. Only longer-lived stars, those that spend several billions of years on the main sequence, are likely candidates for intelligent life. And, as we have just seen, the rotational evidence indicates that it is just such stars, those with masses about that of the sun, that seem to have planetary systems. If Dole's computer simulations are an accurate reflection of reality, many of those planetary systems include earthlike planets.

But even if the galaxy abounds with long-lived stars that have planetary systems, and even if many of those planetary systems include planets like the earth, how many of those postulated planets are indeed capable of supporting life. Su-Shu Huang, a Chinese-born American astronomer, has tried to answer that question by developing a theory of a 'zone of life', a region in the vicinity of a star where conditions are right for the development of life.

Temperature is a major factor in the size of a star's life zone. We assume that liquid water is needed if a planet is to support life. That assumption can be attacked as being too narrow, but most of the evidence that is now available indicates that liquid water is essential for living organisms. Therefore, the life zone of a star is the region where the temperature is high enough to keep water liquid but not high enough to turn water into steam. If we look at our own planetary system, we find an excellent illustration of this principle. Venus is an earthlike planet whose temperatures are too high for liquid water to exist. Mars is an earthlike planet whose temperatures are too low for water to become liquid. The earth nestles in the sun's life zone, and it supports an abundance of life.

When we consider the life zones of other stars, time as well as temperature must be taken into account. It would appear at first glance that large, hot stars have larger zones of life than

small, cool planets. The large star radiates a lot of energy, and so the region in which the temperatures are right for liquid water are also large. By the same reasoning, the life zone around a star that is small and therefore cool will be narrow. Large stars would therefore have more habitable planets within their life zones than small stars.

But when time is added to the equation, the balance swings in favour of smaller, cooler stars, those whose mass is about that of the sun. It is true that a star of this size has a smaller zone of life than a massive star, which means that there is a smaller chance that any planet will be in the zone of life. But if a smaller star – again, about the size of the sun – does have a planet in its life zone, there will be time aplenty for intelligent life to evolve on that planet. A small star spends billions of years on the main sequence. By contrast, a more massive star will probably burn itself out before intelligent life can evolve on any of its planets.

Of course, much of this theorising is sheer speculation. Life could evolve much faster on a planet orbiting a hot star than it does on a planet such as earth. It is known that the rate at which chemical reactions take place speeds up as the temperature rises. The tempo of life, death, and evolution could be rapid on a planet that receives intense radiation from a massive star. We can visualise fast-evolving life-forms that live and die in a day, as summer insects on earth do. We can picture sentient beings moving and thinking at a tempo that makes life on earth look like a slow-motion film.

But the principle of mediocrity steps between us and this kind of speculation. In the search for extraterrestrial life, it is important to think not of what is possible but of what is probable. High-speed evolution on an unearthly planet orbiting a blue-white massive star is not probable. In addition, the evidence of stellar rotation indicates that planetary systems are most likely to form around smaller stars. The most sensible conclusion is that other intelligent species in the universe, if they exist, live on planets like the earth that orbit stars like the sun.

What about binary stars? The standard assumption has been that two-star systems are not suitable for habitable planets because any planets in a binary system would have complex orbits which would move them from freezing cold to boiling heat. In other words, planets in a binary system would move in and out of the zone of life – not a comfortable situation for living organisms. However, recently, Robert S. Harrington of the

US Naval Observatory in Washington has performed some calculations that make the picture appear more optimistic. Harrington found that the orbits of planets around two-star systems could be stable enough to keep planets in the life zone. For example, Harrington calculated that if the solar system was altered by replacing Jupiter with a star as big as the sun, only Mars would be thrown into an unstable orbit. Under the proper conditions, he found, the normal habitable distances for earth-like planets are in the zone of stability for at least some binary stars.

In the midst of all this theorising, it would be nice to have a solid fact or two about other planetary systems – for example, a straightforward astronomical observation of a planet orbiting another star. Unhappily, direct evidence that other planets exist is extremely hard to come by. Unless it is very large, a planet is a negligible object on the cosmic scale. However, it is at least theoretically possible to detect the existence of a planet by its effect on the motion of its star. If the planet is massive enough, its gravitational pull will be great enough to tug the star slightly in its direction during its orbit. A distant observer will not be able to see the planet, but the wobble in the star's motion that is induced by the gravitational pull of the planet will be visible.

Seen from the earth, stars appear to be moving through space. This apparent motion is due to the spin of the Milky Way galaxy. As the galactic disc whirls, the sun goes around and around, as if on a cosmic carousel. Anyone who has ridden a carousel knows that it is possible to create an illusion that everything else is moving. Seen from the earth, stars should move along smooth paths. A wobble in the path means that a star is being tugged by the gravitational pull of another body. As astronomer George Gatewood of Allegheny Observatory in Pittsburgh explains: 'Imagine two people dancing a polka. As they whirl about to the music, each person – pulled by the other – moves in a series of circles across the floor. Now imagine that one of the dancers is invisible; we can still tell he is there by the motion of his partner.'

There are strict limits on this kind of observation. Either the star must be small or its companion must be large. And a star must be relatively near the earth for a wobble to be detected by our astronomers.

The best illustration of the difficulties in the observations of such stellar motions – the field is called astrometry – is the story of Barnard's star, so called because it was discovered in 1916 by Edward E. Barnard of the Yerkes Observatory. Barnard's star is both small and nearby; at a distance of 5.9 light years, it is the second nearest star to earth. For more than three decades, an unusually detailed record has been made of the motion of Barnard's star, a record that is written on some 10,000 photographic plates made at the Sproul Observatory at Swarthmore College in Pennsylvania under the leadership of astronomer Peter van de Kamp. In 1964 van de Kamp announced that the observations indicated that Barnard's star has a planet that is about half again as large as Jupiter, the largest planet in the solar system.

The announcement produced a sensation, because of the nearness of Barnard's star. A few years later, van de Kamp said a re-analysis of his data indicated that Barnard's star actually has two planets, one of them 1.1 times the mass of Jupiter, the other 80 per cent as massive as Jupiter. For a decade, the planet (or planets) of Barnard's star were accepted as the real thing.

Then, in 1976, Gatewood said that van de Kamp was wrong. On the basis of observations made at the Allegheny Observatory and at the Van Vleck Observatory in Connecticut, Gatewood said that the evidence given by van de Kamp for the existence of two planets around Barnard's star was erroneous. But Greenwood added that his observations indicated the existence of a planetary system around Barnard's star – two planets, the size of Jupiter and Saturn. Van de Kamp checked his data again and said that he was right in the first place. At the moment, the issue is still undecided, although the volume of the Sproul observations makes many astronomers lean towards believing van de Kamp.

Somewhat the same story is being played out about Epsilon Eridani, a star whose mass is about the same as that of the sun. Van de Kamp says that there is evidence indicating that Epsilon Eridani is orbited by a planet with six times the mass of Jupiter. Gatewood's observations cast doubt on that possibility.

The debate about astrometric evidence for other planetary systems is likely to go on for some time. As Gatewood pointed out in 1976, astrometry required periods of observation 'similar to the orbital periods of the objects sought'. Those orbital periods

are quite long – 12 and 26 years, respectively, for the planets which van de Kamp believes have been detected around Barnard's star. Astrometrists think in decades.

And they do not think about making contact with civilisations on any planets that they might detect. Such planets are just too big to support the kind of life that we are familiar with. All that astrometry can offer SETI is the possibility that the cosmos is swarming with planetary systems. For example, Helmut Abt of the Kitt Peak National Observatory in Arizona studied 123 stars resembling the sun and concluded that almost all of them had companions. Most of those companions were other stars. By extrapolating from the patterns he observed to smaller masses than he could detect, Abt concluded that as many as one-third of the stars could be orbited by bodies smaller than stars. However, those bodies could not quite be described as planets. Although not large enough to ignite the fusion reactions that would make them stars, they are massive enough to be in gravitational collapse, generating enough energy to remain starlike in appearance for many millions of years.

If Abt's figures are extrapolated down further, the uncertainties became unacceptably large. It is even impossible to use his observations to estimate the number of Jupiter-sized planets orbiting other stars. Earth-sized planets are so small on this scale that they are undetectable.

But there is one place where earth-sized planets are detectable: the solar system. The planets orbiting the sun may be a small sample, but they are all we have. One of them we can examine directly – a convenience, since it happens to be the only one known to support life. The others can be investigated by a variety of methods. And they have a lot to tell us.

CHAPTER FIVE

Once Around the Sun

Mercury we can write off at once: too darned hot. The closest planet to the sun is not at all a likely candidate for life. Mercury is about the size of the earth's moon, and it has an eccentric elliptical orbit that brings it within 29 million miles of the sun at its closest approach and nearly 44 million miles away at its most

distant point. Mercury rotates slowly, making a complete turn only once every 59 earth days. Temperature measurements from earth indicate that the side of Mercury that faces the sun is at about 1800° F, while the dark side is below zero. With these temperature extremes and the virtual absence of an atmosphere, Mercury is about as dead as a planet can be.

Venus is a different story, and a fascinating one. The fascination commences with the strong resemblance of Venus to earth. Venus is about the same size as the earth and has about the same density, indicating that it is made of much the same material. Venus even receives about the same amount of sunlight as the earth does; although Venus is much closer to the sun than the earth is, the thick blanket of clouds in which Venus is swathed reflects a good deal of sunlight into space. In the years when belief in life on Mars captured the popular imagination, scientists such as Svante Arrhenius speculated freely about lush, dripping forests on the surface of Venus, rather like the tropics on earth.

Hell on Venus

Until the middle of the twentieth century, not much was known about the surface of Venus. Now we know a lot – too much, in fact, for those who envision a lush Venus. The disillusionment began in the 1950s with earth-based measurements which indicated that the surface temperature of Venus is at least 500° F, a reading which meant that Venus would also have an atmosphere at least ten times more dense than earth. Those figures seemed surprisingly high at the time. Now they seem conservative.

A series of spacecraft launched by the United States and the Soviet Union have given detailed information about the surface of Venus. The United States concentrated on fly-bys, while the Soviets have sent many probes into the atmosphere and towards the surface of Venus. The US missions confirmed the high temperature and density of the atmosphere. After a long series of failures, the Soviets succeeded in sending a probe into the atmosphere in 1967. It was burned and crushed to death in the hot, dense atmosphere, many miles above the surface. The Soviets made tougher, better-armoured spacecraft; they too, were destroyed by the hostile conditions. In 1970 a Soviet craft, Venus 7, stayed alive on the surface for a few minutes, reporting a temperature of 900° F and a pressure ninety times greater than earth.

Most planetary scientists are certain that Venus does not

support life. Conditions on Venus certainly seem as hostile as could be imagined for terrestrial organisms. The atmosphere consists almost entirely of carbon dioxide, with little or no water. The yellow clouds, many miles thick, in which the planet is wrapped, are believed to be made up of sulphuric acid. And the intense heat and incredibly dense atmosphere make the planet literally hellish.

Some scientists have not given up hope for life on Venus. Bruce Murray, a planetary scientist who heads the Jet Propulsion Laboratory in Pasadena, California, believes that there could be organisms living in the atmosphere of Venus, at an altitude where temperatures are more moderate than they are on the surface. Such organisms could feed on the sulphur compounds in the clouds of Venus, Murray says, spending their entire existence aloft. Murray's idea is imaginative, but the consensus is that life is improbable on Venus.

There have been proposals for making Venus more receptive to terrestrial life, by a major long-term effort in planetary engineering. When the hostile nature of its atmosphere became known, there was some talk of seeding Venus with organisms that could make the planet habitable. A spacecraft would scatter blue-green algae across the upper atmosphere. These microbes would reproduce, spread across the planet, and break down the carbon dioxide of the atmosphere to liberate oxygen. A healthy rain would fall, and Venus would become the tropical paradise of earlier dreams. Those hopes now have been largely abandoned, because of the low probability of an organism surviving the sulphuric-acid attack and the absence of water. If planetary engineering ever is attempted on Venus, some way of importing vast amounts of water must be found, and a number of other problems must be solved. It will not happen soon.

But fascination with Venus still continues, because of the resemblance between Venus and earth. Why should one planet be so hospitable to life and the other be so hostile?

Part of the answer comes from the chemistry of the solar nebula from which the planets formed. John S. Lewis, a geochemist at the Massachusetts Institute of Technology, theorises that different chemicals are present at different distances from the protostar in a solar nebula. The region in which earth formed had water-containing silicates, Lewis said, while the region where Venus formed did not. Earth got water; Venus got none, and that has made an enormous difference.

Aside from water, there is not much potential difference

between the atmosphere of earth and that of Venus. However, the prevailing theory is that planetary evolution followed a far different scenario on Venus. Because it is nearer the sun, Venus gets 1.75 times more solar radiation than the earth. Much of the radiation is reflected away by the thick cloud blanket. But the radiation that enters the atmosphere is trapped in the clouds and in the carbon dioxide atmosphere. On earth, living creatures lock up much of the carbon in such things as seashells. On Venus, the absence of life allows sunlight to liberate carbon from rocks. The carbon dioxide which is formed allows the shorter rays of solar radiation to enter but traps the longer waves of radiation that are reflected by the soil. More carbon dioxide traps more heat, and the heat liberates more carbon to form carbon dioxide. The result is a runaway 'greenhouse effect', so called by analogy with a heat-trapping greenhouse on earth (although a greenhouse actually traps heat by holding hot air beneath its glass).

Could a runaway greenhouse effect happen on earth? Some scientists nervously suspect that it could. All the ingredients are present. If all the carbon in earth's limestone and seashells were liberated, the density of the atmosphere would increase seventy-fold. If the temperature rose enough, water would be broken down into hydrogen and oxygen. The hydrogen would escape from the earth's gravitational pull, and the oxygen would combine with surface minerals. One nightmare is that mankind might manage to upset the ecological balance of earth enough to produce another Venus.

Life on Earth

But earth teems with life, and it appears to have been well stocked with living creatures for billions of years. One of the more encouraging developments for SETI in recent years has been an accumulation of evidence showing that life established itself on this planet with remarkable speed and has flourished under almost every conceivable terrestrial condition.

A scientist who has done a great deal to push back the limits of life on earth is Elso Barghoorn, a palaeontologist at Harvard University. Working with minerologist Stanley Tyler in the 1950s and 1960s, Barghoorn showed that there are fossil microbes in a Canadian rock formation called the Gunflint, which is two billion years old. In 1977 Barghoorn pushed the frontier back considerably further, by showing that a 3.5-billion-year-old rock formation in southern Africa contains fossil microbes that appear

to be primitive forms of algae.

Consider that the earth formed from the solar nebula about 4.5 billion years ago, that millions of years were needed for the evolution of the first molecules of life, that more time was needed for those molecules to form themselves into a primitive cell. One billion years for the appearance of such cells is an impressive performance.

Primitive cells could have appeared even earlier. Late in 1977, Carl R. Woese and some other microbiologists at the University of Illinois said that they had identified a small family of microbes as being distinctly different from all other organisms on earth – different enough to be descendants of the first microbes to have evolved on earth.

Woese's microbes are anaerobic: they do not require oxygen to live. Most microbes and all higher life-forms are aerobic: they require oxygen. The family of organisms studied by Woese has members that are found only in oxygen-free environments: the intestines of ruminant animals, rotting sewage stagnant marshes, hot springs in Yellowstone National Park. The microbes 'breathe' hydrogen and carbon dioxide and excrete methane. Until Woese made his report, these microbes were classified as bacteria. But a long and detailed study of the genetic material of the organisms convinced Woese that they are different enough from other bacteria to constitute a separate form of life. If Woese is right, the standard textbook division of all terrestrial organisms into prokaryotes – simple organisms whose genetic material is not gathered into a cell nucleus – and eukaryotes – more complex organisms which have cell nuclei – must be changed. Now the classification must include another kind of prokaryote, the organisms that Woese tentatively called 'methanogens', as a third life form.

Woese believes that the ancestors of the methanogens evolved about four billion years ago, well before the algae whose fossils were discovered by Barghoorn. If Woese is right, then organised life on earth got off to a running start, not long after the planet began to cool from its fiery beginning. The methanogens breathed in the hydrogen compounds and carbon dioxide of the primitive atmosphere and breathed out methane that entered the evolutionary cycle. As Ponnamperuma said when he heard of Woese's report, 'The idea fits in beautifully with the idea that life began in non-oxygenic conditions.' Score one for the SETI concept of a universe where life is a common occurrence.

Against that possible victory must be marked the apparent

failure to find life on Mars in the Viking mission. However, the hope that there might be some kind of life on Mars is not dead. There is the plain evidence from Viking orbiter pictures that water once flowed in abundance on the Martian surface. Some planetary scientists, like Carl Sagan, have proposed that Mars goes through climatic cycles, in which conditions change from being hostile to life to being friendly and back again. In the past few years, geologists have produced convincing evidence that the earth goes through climatic cycles. The driving force behind these cycles is apparently small irregularities in the earth's orbit and spin. These irregularities affect the amount of solar energy received by the earth enough to cause such large-scale effects as the ice ages.

Mars: the Untold Story

But most planetary scientists now believe that the flow of water on Mars was a once-only phenomenon, something that happened relatively early in the history of the planet. The key to this belief is the relatively small size of Mars, which has half the diameter and only thirty-eight per cent of the gravitational attraction of earth. Assume that Mars, at birth, had the same content as earth of what scientists call 'volatiles' – gases and liquids. Earth had the gravitational pull to hold on to an appreciable fraction of its volatiles; Mars did not. The thinness of the Martian atmosphere does nothing to mitigate the cold of Mars. There is plenty of water on Mars, scientists calculate; the polar caps, under a veneer of dry ice – frozen carbon dioxide – are made of water, and the Martian soil is believed to contain enough frozen water to cover the planet hundreds of feet deep, if it were melted. But water does not melt on Mars. It sublimes – that is, goes directly from ice to vapour – which is not much help to living organisms.

Maybe there is life on Mars, even given all this. Perhaps organisms evolved in the early, lush days, and have burrowed in for survival. We know of microbes on earth that can survive under conditions about as severe as those found on Mars. The Viking spacecraft literally scratched the surface of the planet. Future missions will dig deeper. An optimist such as Carl Sagan can rattle off several scenarios which end with the survival of Martian microbes. The story of Mars is not all told yet.

Assume the worst: that Mars is indeed lifeless. The first reaction is that of bitter disappointment for SETI, because the life zone around the sun appears to shrink. But a closer look allows a

more cheerful interpretation. Edward Anders of the University of Chicago and Tobias Owen of the State University of New York at Stony Brook took a closer look after the Viking mission. They concluded, in a scientific paper, that 'Mars was poor in volatiles from the start' and fell behind earth not only by losing lighter gases but also because more volatiles were – and are – trapped in the Martian soil. But they had this to add:

> If it turns out that Mars is completely devoid of life, this does not mean that the zones around stars in which habitable planets can exist are much narrower than has been thought. Suppose Mars had been a larger planet – the size of earth or Venus – and therefore had accumulated a thicker veneer and had also developed global tectonic activity on the scale exhibited by earth. A much larger volatile reservoir would now be available, there would be repeated opportunities for tapping that reservoir, and the increased gravitational field would limit escape from the upper atmosphere. Such a planet could have produced and maintained a much thicker atmosphere, which could have permitted at least an intermittently clement climate to exist. How different would such a planet be from the present Mars? Could a warm, stable climate be maintained? It seems conceivable that an increase in the size of Mars might have compensated for its greater distance from the sun and that the life zone around our star would have been enlarged accordingly.

In other words, a different role of the cosmic dice might have made this a solar system with two inhabited planets. And since the dice have been rolled billions of times as stars come into being, many planetary systems with more than one habitable planet could exist.

With their habit of thinking big, scientists in SETI have raised the possibility that our solar system may yet be made to have two habitable planets, even if mankind must take a hand. In 1976 a committee of exobiologists working out of the Ames Research Center in California issued a report, 'On the Habitability of Mars: An Approach to Planetary Synthesis', which examined what mankind might do in the way of planetary engineering on Mars.

There is nothing small about the way these scientists think. Is Mars too cold and its atmosphere too small to support life? Then spread sand or dust on the polar ice caps to increase the amount of sunlight they absorb, vapourising the caps to thicken the atmosphere, and raise the temperature. Are terrestrial

microbes unsuited for the rigors of Mars? Then create new microbes, using genetic engineering. ('Indeed, in principle, the entire gene pool of the earth might be available for the construction of an ideally adapted oxygen-producing photosynthetic Martian organism,' the report said.) The time required for all this? Perhaps 100,000 years or more, although the transformation might be accomplished in as little as 10,000 years. The important thing, the committee report said, is that 'no fundamental, insuperable limitation to the ability of Mars to support terrestrial life has been unequivocally identified'. This is really thinking big.

Some scientists extend the life zone of the sun past the four innermost, earthlike planets. Life on the giant outermost planets would have to be very different from life on earth, but a combination of theory observation, and experimentation has produced a scenario for the creation and evolution of organisms on such planets as Jupiter.

Life on Jupiter: Hard to Imagine

Thinking in terrestrial terms will not get us far, because Jupiter is more like the sun than the earth. If the earth is a rock, then Jupiter is a gas Jupiter is massive: more than 300 times the mass of the earth, more than twice as massive as all the other planets put together. The Pioneer 10 and 11 spacecraft that flew by Jupiter in 1973 and 1974 showed that the planet consists mostly of hydrogen and helium, like the sun, although methane, ammonia, and water are also present. Jupiter emits radio waves and heat. perhaps because it is undergoing the kind of gravitational collapse associated with protostars. And Jupiter spins so fast that it is visibly flattened at the poles and bulges out at the equator.

Jupiter completes one rotation every 9 hours and 55 minutes. The speed of its rotation creates the planet's distinctive bands of clouds, whose colours range from yellow to bronze. Earth's slower spin allows clouds to move north and south, producing our changeable weather. On Jupiter, the clouds are trapped into permanent bands, called zones and belts. The Great Red Spot, about whose nature astronomers argued for decades, now is known to be a more or less permanent storm raging in the upper atmosphere, kept going by the enormous forces at work on Jupiter.

When we add to this picture of giant size, gaseous com-

position and rapid spin two other factors, Jupiter's great distance from the sun and evidence of turbulent circulation of gases from the interior of the planet to its upper atmosphere, life on Jupiter seems difficult to imagine. But if we abandon terrestrial concepts, the unimaginable seems possible.

After all, Jupiter has what are regarded as the essentials of life: heat (at a certain level of its atmosphere), water, a reducing atmosphere of the kind that existed on the primitive earth, and organic molecules. In addition to ammonia and methane, ethane and acetylene have been found in the Jovian atmosphere, and it is possible that more complex hydrocarbons are produced there. The colours of the belts and zones could be explained by the presence of complex organic molecules; the Great Red Spot could be a collection of such compounds. Ample energy is available in the form of lightning discharges, ultra-violet light, and heat to help those compounds start on the road to life.

If there is life on Jupiter, it would have to float in the air, because Jupiter has no solid surface. However, floating organisms are not an impossibility. There is a floating life of a sort on earth, in the oceans, and life in the clouds seems achievable. In 1976 a group of scientists headed by Robert L. Dimmick of the University of California at Berkeley put a terrestrial species of bacterium in a six-foot rolling drum and kept the microbes suspended in air. The bacteria were fed by blowing in mists of sugar. They managed both to eat and to reproduce while floating. In other experiments, Ponnamperuma has exposed terrestrial microbes to the great variations in temperatures and pressures that might be encountered while floating in the Jovian atmosphere. Most of them survived.

Carl Sagan and a Cornell colleague, E. E. Salpeter, recently described a possible Jovian ecology that has three kinds of hypothetical organisms living an aerial life on Jupiter: sinkers, floaters, and hunters. The sinkers reproduce as they drift downwards from the upper atmosphere. They provide food for the floaters, which stay at middle levels. The hunters, which could be gaseous, low-density organisms that are miles across, move in the atmosphere by pumping out helium to achieve jet propulsion. This Jovian ecology, weird as it seems, is simply the ecology of the earth's oceans translated to the atmosphere and chemistry of Jupiter.

Saturn, while similar in composition to Jupiter, is not as good a possibility for life. Saturn is more distant from the sun, and so is colder. It does not generate as much internal heat as Jupiter.

But exobiologists believe they could have a live prospect in Titan, the largest of Saturn's ten moons.

Titan: a Possibility

Titan is big for a satellite but small for a planet; its diameter is 3600 miles, compared to 4200 miles for Mars But Titan is big enough to have an atmosphere. which is known to contain methane and probably hydrogen. The atmospheric pressure on Titan is about one per cent that of earth – 'the most earthlike atmospheric pressure in the solar system,' says Carl Sagan.

Like Mars, Titan is red. Mars is red because it is rusty but Titan is not a rocky body like Mars. It has a low density, and it appears to consist of a mixture of water and ice. The reddish colour of Titan is believed to be due to organic molecules in its atmosphere, which is similar to that of the primitive earth. And Titan is a lot warmer than it should be, apparently because of a greenhouse effect due to its atmosphere. The general belief is that the relatively high temperatures on Titan are found only in Titan's upper atmosphere, and that its surface temperatures are well below freezing. But measurements are uncertain enough to keep alive the possibility that the surface of Titan is warm by terrestrial standards.

Putting together all the could-bes and might-bes, Titan, like Jupiter, becomes an interesting spot for exobiologists. A trip to Titan is fairly high on the list of future missions that planetary scientists would like to fly. Until then, Titan is a grand subject for speculation, the stuff that science fiction scenarios are made of (like Kurt Vonnegut's *The Sirens of Titan*, which does have a habitable Titan).

So a quick sweep of the solar system for life shows one sure thing (earth), one apparent near-miss (Mars), and two outside chances (Jupiter and Titan); not a bad batting average at all. That record is something to keep in mind as we move away from the sun and consider SETI from the galactic point of view.

CHAPTER SIX

The Formula

The formula was devised in 1961 by Frank Drake of Cornell. Although it really tells us mostly what we don't know, it quickly became a cornerstone of SETI, something to build on. When a pioneering international meeting on communication with extra-terrestrial intelligence was held in Armenia in 1971, the participants spent a good deal of their time defining the subject by going through the formula, term by term.

It is a remarkable formula. Its purpose is to give a reasonable estimate of the number of civilisations in the galaxy which have the technological ability to communicate with other civilisations. The formula is:

$$N = R_* f_p n_e f_l f_i f_c L$$

The number of technological civilisations in the galaxy is designated as N. On the right side of the formula, R_* is the number of new stars that are formed in the galaxy every year; f_p is the fraction of stars that have planetary systems, n_e is the average number of planets in such systems that can support life; f_l is the fraction of planets on which life actually occurs; f_i is the fraction of such planets on which intelligent life arises; f_c is the fraction of those planets on which intelligent beings learn how to communicate with other civilisations; and L is the average lifetime of such technical civilisations. Multiply all the terms on the right and we have an estimate of the number of civilisations in the galaxy that are capable of communicating with other advanced civilisations.

But there is a problem in applying the formula: the estimates of the numerical values of the various terms in the equation are vague, at best. Astronomers are used to dealing with large numbers which require large margins for error; a billion or so of anything is small change in astronomy. The habit of using astronomically large and elastic numbers is common in SETI. Take the basic question of the number of stars in our galaxy. The standard answer when the question is raised is 100 billion, a nice round number. But when an argument requires it, an astronomer may casually change that to 250 billion stars. After all, it will be

explained, these things are not fully understood, and either number is in the ball park.

Rough guesses are commonplace because a staggering amount of knowledge is needed for more precise measurements. At the 1971 meeting in Armenia, one of the hosts, V. A. Ambartsumian, pointed out what would be needed for a complete answer. The factor R_* is studied by astrophysics, he said, as if f_p, while n_e requires both astronomy and biology. An estimate of the value of f_l requires a knowledge of both organic chemistry and biochemistry, while f_i can be fixed precisely only with the help of neurophysiology and knowledge about the evolution of advanced organisms. As for f_c, an estimate of its value requires data from anthropology, archaeology and history. Finally, the value of L is nothing less than the major question now facing mankind. Can an advanced technological civilisation of our kind survive for a long period? Will we destroy ourselves in any one of a dozen technological ways? Will we cease to be a technological civilisation by turning away from technology? Not only for L, but for every factor in the equation, there are many unanswered questions. Answering them requires information from almost every scientific discipline. 'It is remarkable,' said Ambartsumian, 'that there exists a single problem that involves so intimately subjects ranging from astrophysics and molecular biology to archaeology and politics.'

But even if a great deal of the needed information is not available, a start must be made somewhere. We have some data, although it is imperfect. To start with R_*, our galaxy is believed to be about 10 billion years old and contains about 100 billion stars. Therefore, an average of 10 new stars a year have formed during the lifetime of the galaxy. But that does not mean that the current rate of star formation is 10 stars a year. It can be assumed that more stars formed in the early years of the galaxy than form now, when the galaxy is mature. A reasonable estimate for the rate of formation of new stars in the galaxy today is about one a year. If this value is correct, then R_* equals one. There is plenty of margin for error in that value. An estimate of three new stars a year in our galaxy would not draw a violent argument for most astronomers. But one a year is an acceptably conservative estimate.

How many of those stars have planetary systems? Again, rough estimates are necessary. As was pointed out earlier,

the evidence of stellar spin indicates that a rather large fraction of moderate-sized stars could have planetary systems. There are all those stars whose mass is about that of the sun and which spin more slowly than their masses indicate they should. In the case of the sun, astronomers are reasonably certain that the missing angular momentum was transferred from the star to its planets. But it is not at all certain that the same thing happened to all the other slow-spinning stars.

There is an alternative explanation that does not include the formation of a planetary system. Perhaps the angular momentum of a protostar is transferred to gas and dust that spirals out from the star without forming planets. Since there is almost no observational evidence of the existence of other planetary systems, we do not know how often a star lost angular momentum without gaining planets. Estimates of the fraction of sun-sized stars that have planetary systems range from one in ten to as high as five in ten. Therefore, the value of f_p could be anything from one to five.

For an estimate of the next term in the formula, the value of n_e, the fraction of planets that can support life, we have some evidence from the solar system. Earth can support life. Mars is a 'maybe'. Jupiter is another 'maybe', although a stretch of terrestrial standards is needed. The most optimistic reading is that three of the nine planets are capable of supporting life. For the galaxy at large, we can pick an estimate starting at one planet in ten and running up to four planets in ten, as the value for n_e.

The next term, f_l, is the fraction of such planets on which life actually does arise. In setting a value for this term of the equation, exobiologists tend to be optimistic. Since the universe seems to be liberally seeded with the starting molecules of life, since living organisms appeared so early in the history of earth, and since there is no reason to believe that a planet like earth in another planetary system would undergo a different kind of early history, it is assumed that the value of f_l is high. Carl Sagan typically sets the value of n_e at one – meaning that life inevitably arises on any planet capable of supporting life. More conservative estimates are that life exists on one in every two or one in every four suitable planets.

Once primitive living organisms come into existence on a planet, what are the chances that intelligent life will evolve? There are wide differences of opinion about the value that should be set on this term of the equation, f_i. The noted palaeontologist

George Gaylord Simpson, an expert on evolution, has said that the chances of intelligent life arising elsewhere are very low. In effect, Simpson rejects the assumption of mediocrity. He believes that the earth is 'appallingly unique', at least when we consider the long and complex sequence of events that led to the evolution of the human race.

Simpson's is a minority view. Most workers in SETI believe that while the exact sequence of events that produced the human race may be unique, the general evolutionary pathway that leads from primitive life forms to intelligent beings could be common. John Lilly, a biologist who rhapsodises about the personality of dolphins and who did extensive work on their intelligence, believes that intelligent beings have evolved on earth by two separate pathways: one for humans, one for dolphins. (But his proposition, if true, does SETI no good because dolphins, however intelligent, are determinedly untechnological.) On the other hand, scientist-writer Isaac Asimov has said that the evolutionary pathway on another planet is bound to be so similar to that of earth that its intelligent beings will have an overall resemblance to humans – one head, two arms, two legs. Asimov reasons that the value of having a central brain, hands to do fine manipulations, and legs to manoeuvre with are so great that the basic design is likely to be repeated again and again.

Given this diversity of opinion, the values set by different people for f_i differ widely. The value of f_i has been set as high as one – meaning that intelligent life will evolve on any planet where life arises – and as low as .01, meaning that intelligent life will evolve on only one in a hundred of such life-bearing planets. No value between one chance in a hundred and a hundred chances in a hundred need be rejected. In fact, if Lilly is correct, the value of f_i may be higher than one, since intelligent life may evolve more than once on the same planet.

Once intelligent life arises, what is the probability that a civilisation will be created that has both the technological capability and the desire to communicate with other civilisations? The value that any observer sets on this factor, f_c, depends on that observer's world view. A view that is almost standard in SETI puts technology at the peak of human achievement and adds the assumption that technology is the essential tool of an ever-curious, ever-questing, ever-expanding intelligent race. From this point of view, the rise of a technological civilisation is the logical goal of any intelligent species, and the desire of such a

species to move from its home planet into the frontier of the universe is unquenchable.

An alternative point of view that has gained some support in recent years holds that technology is as much a curse as a blessing. From this point of view, the 400-year-old European effort to conquer nature through science and technology is not the goal of human life but an aberration from which the human race must recover. The current estimate of the value of f_c tries to balance these two views. It is believed that only a minority of intelligent species will attempt to communicate with life on other planets. The value of f_c is set at something between one in ten and five in ten.

L=The Major Question Facing Mankind

At this point, it must be confessed that the values set for the first six terms of the right side of the equation are not very meaningful. Most of the values are so elastic that the results of multiplying them can give any result over an enormously wide range. What the people in SETI usually do is to juggle the values so that the result comes out at unity – 1. This method makes the value of L the most important factor in the equation. If the value of L is high, there are many communicating civilisations in the galaxy. If the value is set low enough, we can conclude that we humans are alone – in the sense that we are the only species with both the ability and the will to communicate with other civilisations that exist at this time in the galaxy.

The last statement does not mean that the human race is the only communicating species to have existed in the history of the galaxy. In the billions of years that the universe has been in existence, millions of technological civilisations may have come into existence on planets scattered through the galaxy. But if those civilisations tend to lose their ability to communicate in a matter of centuries, the odds that two of them will be in existence at the same time is small. And since the galaxy is immense, the odds are even smaller that two such short-lived civilisations will be close enough to make contact even if they have their brief flowering at the same time. Communication with extraterrestrial intelligence is likely only if technological civilisations have lifetimes measured in many thousands of years.

As it happens, the lifetime of a typical technological civilisation is not only the central issue of SETI but also the central issue of

mankind today. The only technological civilisation which we can study to set a value for L is ours. Mankind can end the SETI debate by destroying its technological capability, either by any one of the toxic by-products of technology or by simply losing interest in technology. In that case, the value of L is a few tens of years, and the case for SETI is closed. Or mankind could manage to fulfil the vision of a planet that maintains its prosperity and its technological drive. In that case, mankind can look forward to making contact with another advanced civilisation sooner or later.

However, mankind's fate cannot be accepted as the fate of all other intelligent species that may have existed in the universe. Iosif Shklovsky, a Soviet leader in SETI, has made the point that many societies may destroy themselves in a fairly short time, but that some small fraction of intelligent societies might be able to solve the multitude of problems that face a technological civilisation. These successful societies might then survive and advance for many thousands or even millions of years. At the meeting in Armenia, Shklovsky put the value of L at above 50 years and under one million years.

Shklovsky and everyone else at the meeting agreed that all estimates are not better than guesses. But an estimate of the possible number of communicating civilisations in the galaxy can be made on the bases of those guesses.

Assume that all the terms but L on the right side of the equation, when multiplied, give an answer of 1. This means that one communicating civilisation comes into existence every 10 years. If the average lifetime of an advanced civilisation is 10 million years, then there are about one million communicating civilisations in the galaxy. (If that number seems large, realise that it works out to one communicating civilisation for every 100,000 stars.) If the average lifetime is 100,000 years – we hesitate to say 'only' 100,000 years knowing the present state of mankind – then there are 10,000 communicating civilisations in the galaxy.

Individuals in SETI have speculated almost endlessly about the value of L and the number of advanced civilisations that now exist. Those speculations, made to look more formidable by complex mathematics, can lead to almost any answer at all. Estimates have ranged from millions of communicating systems in the galaxy down to just one – us.

Just recently, these estimates have come to be of practical importance. After several decades in which the search for extraterrestrial life was financed in no formal way, US scientists in the

field have begun to ask for federal appropriations. When they ask for money, they must make some statements about how long the search might take. Obviously, the length of the search is directly related to the number of communicating civilisations in the galaxy. If there are millions of communicating civilisations, they are relatively close together and a relatively short period will be needed to make contact (if we know enough to go about the search in the right way). But if there are relatively few communicating civilisations in the galaxy, the effort to make contact may take almost forever, in practical terms.

'Relatively' is the important word here. 'Long' and 'short' have different meanings for congressmen and other laymen than for astronomers, who are used to working with very large distances and very long periods in time. A time interval that sounds reasonable to someone in SETI may impress someone outside the field as being preposterously long.

Take the estimate made by Carl Sagan at the meeting in Armenia that there might be 100,000 technical civilisations in the galaxy. As we have seen, this is a middle-of-the-road number, by the standards of the formula. To the novice, 100,000 civilisations is an encouragingly large number; the galaxy is full of them. And yet it means that the distance between civilisations is depressingly large by everyday standards; the distance would be on the order of hundreds of light-years. The time required for two civilisations to make contact would be correspondingly long. If earth were to intercept a message from a civilisation at that distance tomorrow and if a return message were sent immediately, the response from the other civilisations would not arrive until roughly the twenty-fifth century. But there is a more basic consideration: if civilisations are so distant from one another, the odds of them making contact are correspondingly small because the number of stars that each civilisation must scan before finding intelligent life is large.

The prospects of obtaining the money for the protracted effort needed to communicate with another civilisation thus would not be bright. Ronald Bracewell of Stanford University, a freewheeling member of the SETI community, makes the point that most governments are not eager to spend large amounts of money for many decades or centuries on the chance that some indefinable benefit might result in the indefinite future.

Interestingly enough, we now can begin to judge the strength of Bracewell's arguments ourselves. Requests to spend relatively modest amounts of money on a search for extraterrestrial life

now are before both the American Congress and the appropriate officials in the Soviet Union. The scientists who are making the proposals believe that these first searches should be just the prelude to more long-lasting and more expensive efforts. While they are usually discreet enough not to say so directly, the scientists are fully prepared to look for decades or even centuries, and to spend billions of dollars in the search. For the time being, they are asking only for a few millions and are having limited success. If the number of communicating civilisations in the galaxy is small, the real test of Bracewell's argument will come in a few years, when the preliminary search has given negative results and the searchers come back to ask for more money.

Thus, if the value of N in the formua is small, the difficulty facing SETI is one of maintaining public interest and public financing for a long, long time. But if the value of N in the formula is calculated to be large, another difficulty arises – a difficulty that not only has more immediate consequences but also is more enthralling to most people.

Where Are They?

If one assumes that there are millions of advanced civilisations in the galaxy and that the distances between them are not great – a few tens of light-years – there is an embarrassment of riches. If all those civilisations are out there, and if they have advanced technological capabilities, why haven't we heard from them by now? More than thirty years ago, physicist Enrico Fermi asked the question very bluntly: 'Where are they?'

Some ingenious answers have been proposed for that question. But the simplest answer of all, and the answer that has the most attraction, can be read almost any day in a newspaper or magazine. That answer is: They're here already. (There is a variation on that theme, which has led to any number of best-selling books: They were here a while ago, but they left.)

For several decades now, observers all around the world have been sighting strange objects in the sky. Long accounts of such sightings are being published constantly. Many of those accounts include details of meetings with beings who are aboard the strange objects. A sizable portion of the American population has at least a sneaking belief that these objects may be visitors from another planet. This belief has created a large market for stories about Unidentified Flying Objects and has given birth to a subsidiary publishing industry which is based on the thesis that

the reminders of ancient space travellers are all around. Since the purpose of SETI is to make contact with another advanced civilisation, it seems prudent to examine the possibility that contact has already been made, either in the distant past or in the present.

CHAPTER SEVEN

Who Goes There?

On 24 June 1947, Kenneth Arnold, a businessman from Boise, Idaho, was flying his private plane over the state of Washington when he saw what appeared to be some unfamiliar aircraft near Mount Rainier. Although the aircraft were at least twenty miles away, Arnold reported later that he could see them quite clearly 'flying like geese in a diagonal chainlike line, as if they were chained together'. The chain was at least five miles long, Arnold said, and it consisted of 'saucerlike things . . . flat like a piepan and so shiny they reflected the sun like a mirror'.

Arnold later changed his description to say that the objects were crescent-shaped and had wings, but his early phrase, publicised by William Bequette, a reporter on the *Pendleton East Oregonian*, caught on. The 'flying saucer', later to become the Unidentified Flying Object, had been born.

They're Already Here

More than three decades later, UFOs are still a topic of lively discussion on the fringe of science. The field of ufology, as its devotees call it, has several privately funded investigative groups and supports several magazines. Books on UFOs appear regularly. Ufology conventions are well attended. No day goes by without a UFO sighting, and hardly a month goes by without a long, detailed account of a human meeting with occupants of an alien spacecraft. A poll in 1976 found that some fifteen million Americans have seen UFOs at one time or another and that a clear majority believes that UFOs are real. There even appears to be some underground sentiment in favour of UFO studies in the scientific community. In 1977 Peter A. Sturrock, an astrophysicist at Stanford University, found that eighty per cent of the nearly

1400 members of the American Astronomical Society who responded to a questionnaire felt that the UFO problem 'certainly . . . probably . . . or possibly . . . deserves scientific study'. Sixty-two of those who replied said they had witnessed an event that they thought might be related to the UFO phenomenon.

Ufology is certainly one of the more interesting phenomena of our time. Officially, the subject has been written off as unworthy of serious scientific examination. The great majority of those in SETI say that ufology belongs more in the field of mass psychology than in astronomy. (The results of Sturrock's poll can be explained as a standard example of a biased sample – that is, only those with an interest in UFOs were likely to return the questionnaire.) It is certainly true that proclaiming a belief in UFOs is not the best way to forward a career in science. The case of James MacDonald is an extreme example of that fact.

MacDonald was the senior atmospheric physicist in the University of Arizona's Department of Atmospheric Sciences. A long private study convinced him that UFOs are of extraterrestrial origin. During the 1960s, he gave a number of lectures on UFOs and even got a National Academy of Sciences grant to support his UFO research. All the while, MacDonald carried on his research in the atmospheric sciences. In 1971 he was called before a House of Representatives committee that was studying the proposed US supersonic transport. MacDonald testified about his atmospheric research, which had led him to believe that the SST would damage the earth's ozone layer and thus would cause an increase in skin cancers – a finding, incidentally, which now is widely accepted.

In the questioning that followed, the discussion was steered to the UFO issue. MacDonald described his belief that there is a connection between UFO sightings and electric power failures. That statement was used to ridicule his testimony about the effect of the SST on the ozone layer. MacDonald committed suicide later that year.

Welcome to Ufology

Ridicule remains a standard scientific response to belief in UFOs, for what scientists regard as very good reasons. One can appreciate those reasons by stepping into the world of ufology. From the outside, ufology may appear to be a sober subject. On the inside, it is a fabulous garden of exotic growths, full of a lush underbrush with many hidden traps. Ufology is not

a unified movement, to say the least. It has its conservative wing, which is dedicated to proving the extraterrestrial hypothesis, and any number of other wings that can be difficult to describe. In a UFO magazine, technical reports on the authenticity of UFO pictures rub shoulders with articles on 'How to Be Captured by UFOlk' ('. . . make yourself available. Many UFOlk can read your mind. They know if you're willing.') and reports of miraculous healings effected by humanoids. Proposals that UFOs are manifestations of demonic activity get the same grave consideration as theories about the planetary origin of extraterrestrial visitors. Books proposing that the earth is hollow and that UFOs come from the interior are reviewed. Advertisements invite readers to 'unlock your hidden powers' or to send away for 'over 100 ready-to-use mystic chants for money, power and love'.

In this atmosphere, it is difficult to recall the early Cold War days when UFOs were taken seriously as a possible threat to US national security. In the rash of sightings that followed Kenneth Arnold's original report, the US Air Force set up what is called Project Saucer to investigate UFOs. It was a time when Americans had fresh memories of a war in which secret weapons had been quite real: the V-2 rocket, the jet plane, the atomic bomb. For a time, a security classification was placed on the military investigation of UFOs.

The First 'Projects': Saucer, Sign, Grudge, Blue Book

The urgency wore off as the years passed. Project Saucer gave way to Project Sign, which was followed by Project Grudge and then by Project Blue Book. For a time, at least some Air Force investigators believed that the extraterrestrial hypothesis was tenable. That time passed, as familiarity with the objects grew. By the early 1960s, the Air Force was being criticised about UFOs from both sides: some felt that the Air Force was not devoting enough effort to the study, others that UFOs were not worth an effort at all.

In 1966, the Air Force decided to let an independent scientific investigation settle the issue. The man chosen to lead the enquiry was Edward U. Condon of the University of Colorado, one of the most eminent physicists in the country. Condon clearly was doing himself no good by agreeing to take on the job. As a 1966 letter from Thurston E. Manning, a vice-president of the university, explained, 'there was an understandable reluctance on the

part of many scientists to undertake such a study . . . the subject had achieved considerable notoriety over the years'.

Condon, who had already proved his toughness by surviving a smear by the House Committee on Un-American Activities during the McCarthy years, got all the trouble that could have been anticipated. Part of the trouble was due to the university's obvious distaste for the project. Robert Low, assistant dean of the university's graduate school, wrote a memo about the possible effect the Condon study might have on the university's image. The memo read in part:

> In order to undertake such a project, one has to approach it objectively. That is, one has to admit the possibility that such things exis . It is not respectable to give serious consideration to such a possibility . We would lose more in prestige in the scientific community than we could possibly gain by undertaking the investigation . . . Our study would be conducted almost exclusively by non-believers who, although they couldn't possibly prove a negative result, could and probably would add an impressive body of evidence that there is no reality to the observations. The trick would be, I think, to describe the project so that, to the public, it would appear a totally objective study, but, to the scientific commun ty, would represent the image of a group of non-believers trying their best to be objective but having an almost zero expectation of finding a saucer . . .

The memo was found in the project's files by Norman E. Levine, a member of the staff. He showed it to David R. Saunders, one of the psychologists on the staff. Saunders was a member of NICAP, the National Investigative Committee on Aerial Phenomena, a private organisation devoted to proving the extraterrestrial hypothesis. Levine and Saunders passed the memo on to NICAP, and it soon was published. Condon fired both Levine and Saunders for leaking the document.

The Condon Report

Criticism from UFO believers was inevitable. Condon's final report, issued as the *Scientific Study of Unidentified Flying Objects* on 8 January 1969, increased the criticism. In the second paragraph of the report, which ran nearly a thousand pages,

Condon said:

> Our general conclusion is that nothing that has come from the study of UFOs in the past 21 years has added to scientific knowledge. Careful consideration of the record as it is available to us leads us to conclude that further extensive study of UFOs probably cannot be justified in the expectation that science will be advanced thereby.

Before the report was issued, the US Air Force had it evaluated by a committee of the National Academy of Sciences. The special committee said in its report:

> We are unanimous in the opinion that this has been a very creditable effort to apply objectively the relevant techniques of science to the solution of the UFO problem . . . On the basis of present knowledge the least likely explanation of UFOs is the hypothesis of extraterrestrial visitations by intelligent beings.

The Air Force then announced that it would close down Project Blue Book and get out of the UFO investigation business. Officially, that ended government action on UFOs. For example, if you call the National Aeronautics and Space Administration with a UFO report today, you will be referred politely to NICAP. Unofficially, the world of ufology teems with rumours that one government agency or another – the FBI, the CIA, or someone – is still active in the UFO field. One recurring theme in ufological discussions is that of the Man in Black, an ominously threatening caller from an unidentified government agency who uses threats to silence observers of particularly exciting UFO events. Few ufologists can name someone who has actually spoken to a Man in Black; generally, the menacing figure is glimpsed ducking around a corner or dodging behind a pole, at some distance. Nevertheless, the Man in Black is believed to be a constant presence.

Although Condon took pains to point out that he had sought the widest possible scientific support, every aspect of his report was criticised by ufologists. The flavour of the criticism can be described by the title of the *Look* magazine article that John G. Fuller, a prolific writer, based on the leaked Low memorandum: 'Flying Saucer Fiasco; The Extraordinary Story of the Half-Million-Dollar "Trick" to Make Americans Believe the Condon Committee Was Conducting an Objective Investigation'.

The heart of the Condon report was a case-by-case study of UFO sightings. Ufologists have two criticisms of the studies: first, that Condon chose only cases that could be easily explained; and second, that many of the cases are listed as being unexplained. Most ufologists say they are willing to concede that 90 per cent or more of UFO sightings can be explained by natural causes. But they dispute the Condon thesis that the other 10 per cent or so could also be explained by natural causes, given enough time and effort. Ufologists rest their case on (a) the small percentage of UFO sightings which they say have no possible natural explanation, and (b) a body of what are described as reliable reports of personal contacts with extraterrestrial creatures.

Opinions differ about the personal-contact cases. NICAP tends to be sceptical about them. But APRO, the Aerial Phenomena Research Organisation, headed by James and Coral Lorenzen of Tucson, is less conservative. 'Abduction cases are at least mind-boggling,' James Lorenzen told one interviewer. Of one personal contact report, he said, 'I don't know if it came from another civilisation, but a human was aboard something under very unusual circumstances.'

One's first reaction is to be impressed by the number of UFO sightings that ufologists say are unexplainable by usual means. A computer bank at the Center for UFO Studies, established by J. Allen Hynek in Chicago, lists 80,000 such cases, including 800 personal-contact stories.

Hynek's own story, which is entirely terrestrial, is a history of the UFO movement in itself. He appeared on the UFO scene in the very earliest days, when he was an astrophysicist on the faculty of Ohio State University; the Air Force hired him to investigate the Arnold report and the early sightings that followed. He remained an Air Force consultant on UFOs until the Condon report ended the Air Force investigation of UFOs. Hynek then became what can best be described as a UFO freelancer, founding the centre, writing and talking on the subject frequently. Most recently, he became prominent as technical adviser to the film, *Close Encounters of the Third Kind.*

In the 1950s and the 1960s, Hynek stressed the possible extraterrestrial origin of UFOs. In the 1970s, he has widened the possibilities. A book which Hynek wrote in 1972, *The UFO Experience: A Scientific Inquiry*, and which proposed a major international effort to gather and study data about UFOs, contained a mention of 'extraterrestrial visitors or the more esoteric notions of time travel or parallel universes' as equally eligible

explanations of UFOs. A later book, *The Edge of Reality*, which Hynek wrote with another long-time ufologist, Jacques Vallee, leaned more towards a psychic explanation. In an interview, Hynek spoke of UFOs as a possible link between 'two parallel realities'.

Wilder Music: The UFO Craze

And that is one of the problems in trying to evaluate the extraterrestrial hypothesis of UFOs: wilder music is being played in the background. At the First International UFO Congress, held in Chicago in June 1977, most of the sessions were devoted to the extraterrestrial hypothesis. But there was a 'symposium on contactee phenomena' that included talks titled 'The Contactees' Psychic World', 'The Virgin Mary – Ufonaut Extraordinary', 'UFOs and the Fairy Faith', and 'Revelations of the Space Brothers'. Jacques Vallee, Hynek's collaborator in writing, delivered the talk on the 'fairy faith' as well as a lecture outlining his belief that 'human beings are controlled by some sort of superhuman consciousness somehow involved with the UFO problem'.

Hynek spoke twice at the congress, including a summary address on 'The Future of Ufology'. Kenneth Arnold, billed as 'the man who started it all' was there. Another session was on George Adamski, who maintained that he met earthlike visitors from Venus in the California desert in 1952, that in a later meeting he was taken aboard a spacecraft by two other space visitors, also earthlike, who identified themselves as being from Mars and Saturn, respectively, and that they all flew to a 'mother ship' that took him to the moon, 'in which vegetation, trees, and animals thrive, and in which people live in comfort'.

But this sort of bizarre buncombe is not the face that ufology usually presents to outsiders. On the rather rare occasions when UFOs break into scientific forums – usually when a believer's letter is published in a journal – the psychic aspects of ufology generally are slighted. Investigations by non-believers also ignore such possibilities as parallel realities and psychic phenomena, concentrating on the extraterrestrial hypothesis.

Investigations of UFO reports by people outside the world of ufology are not common. Most scientists ignore the subject, on the grounds that they have much better ways to spend their time. (One notable exception was the late Donald H. Menzel, a distinguished astronomer at the Harvard College Observatory

who spent a great deal of time on UFOs and whose last book, *The UFO Enigma*, written with Ernest H. Taves, summed up his reasons for scepticism.) Only a few non-believers are willing to spend the time and energy needed to check out UFO reports. Perhaps the leading sceptical investigator of UFO cases is Philip J. Klass, senior avionics editor for *Aviation Week and Space Technology* magazine. A combination of technical knowledge and diligence makes Klass unusually qualified for his self-chosen work.

Case Histories

Two cases will give an idea of how exhaustively Klass can go into a report of a UFO sighting. One is the case of the UFO that reportedly was seen near McMinnville, Oregon, on 11 May 1950, by a Mr and Mrs Paul Trent. The Trents said they had taken two pictures of the objects. William K. Hartmann, the chief photoanalyst for the Condon study, examined the pictures and reported: 'This is one of the few UFO reports in which all factors investigated, geometric, psychological and physical, appear to be consistent with the assertion that an extraordinary flying object, silvery, metallic, disc-shaped, tens of metres in diameter, and evidently artificial, flew within sight of two witnesses.'

Nearly twenty years after the McMinnville incident, Klass obtained copies of the two photos. They were examined by Robert Schaeffer, a colleague of Klass's, who established: (a) that the shadows in the pictures indicated that they had been taken in the early morning, rather than in the late afternoon as the Trents said, and that (b) one picture which the Trents said had been taken a few seconds before the other had actually been taken several minutes earlier. Klass took the analysis to Hartmann, who said that the new information 'removes the McMinnville case from consideration as evidence for the existence of disc-like artificial aircraft', his phrase for UFOs.

An even more unusual case was the incident in which an Air Force RB-47 jet bomber apparently was followed for 90 minutes and 700 miles as it flew from Mississippi to Oklahoma on 17 July 1957. Not only were the crew members able to see the UFO as a bright light in the early-morning sky, but the object also was detected on radar. A long and exhaustive investigation by Klass has led him to believe that the radar signals picked up by the RB-47's equipment actually originated with ground-based radar stations in the area, and that the lights seen at various times by

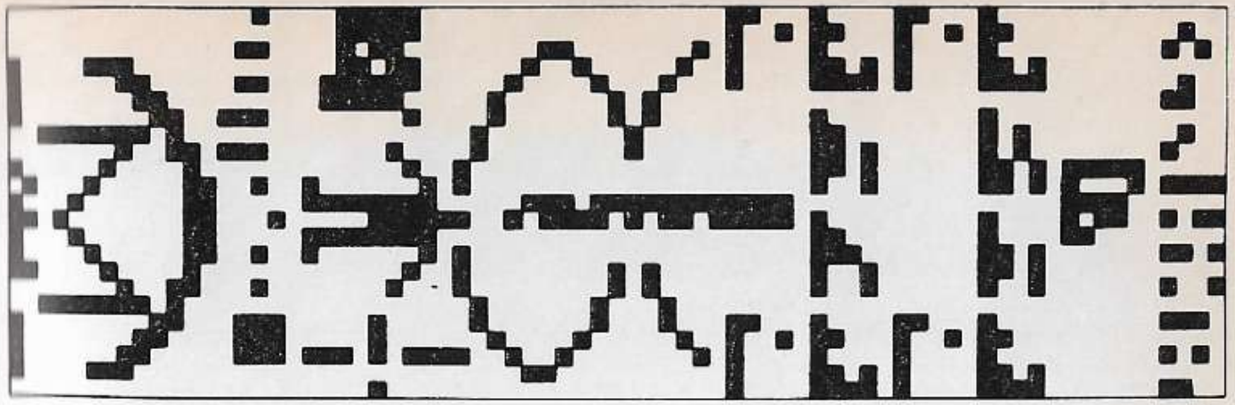


FIGURE 2 The message sent by the Arecibo radio telescope on 16 November 1974.

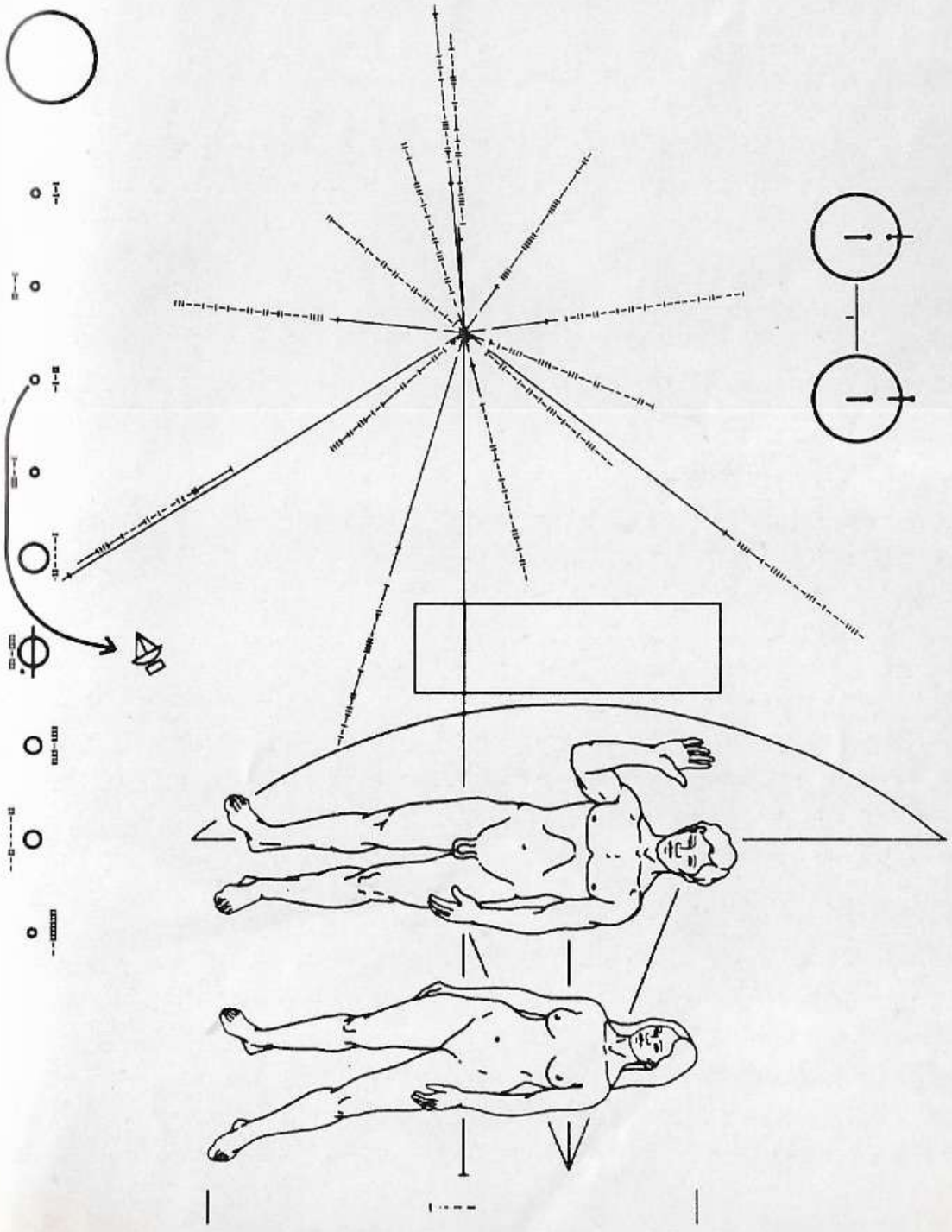


FIGURE 3 The plaque carried into space by the Pioneer 10 and 11 spacecraft.

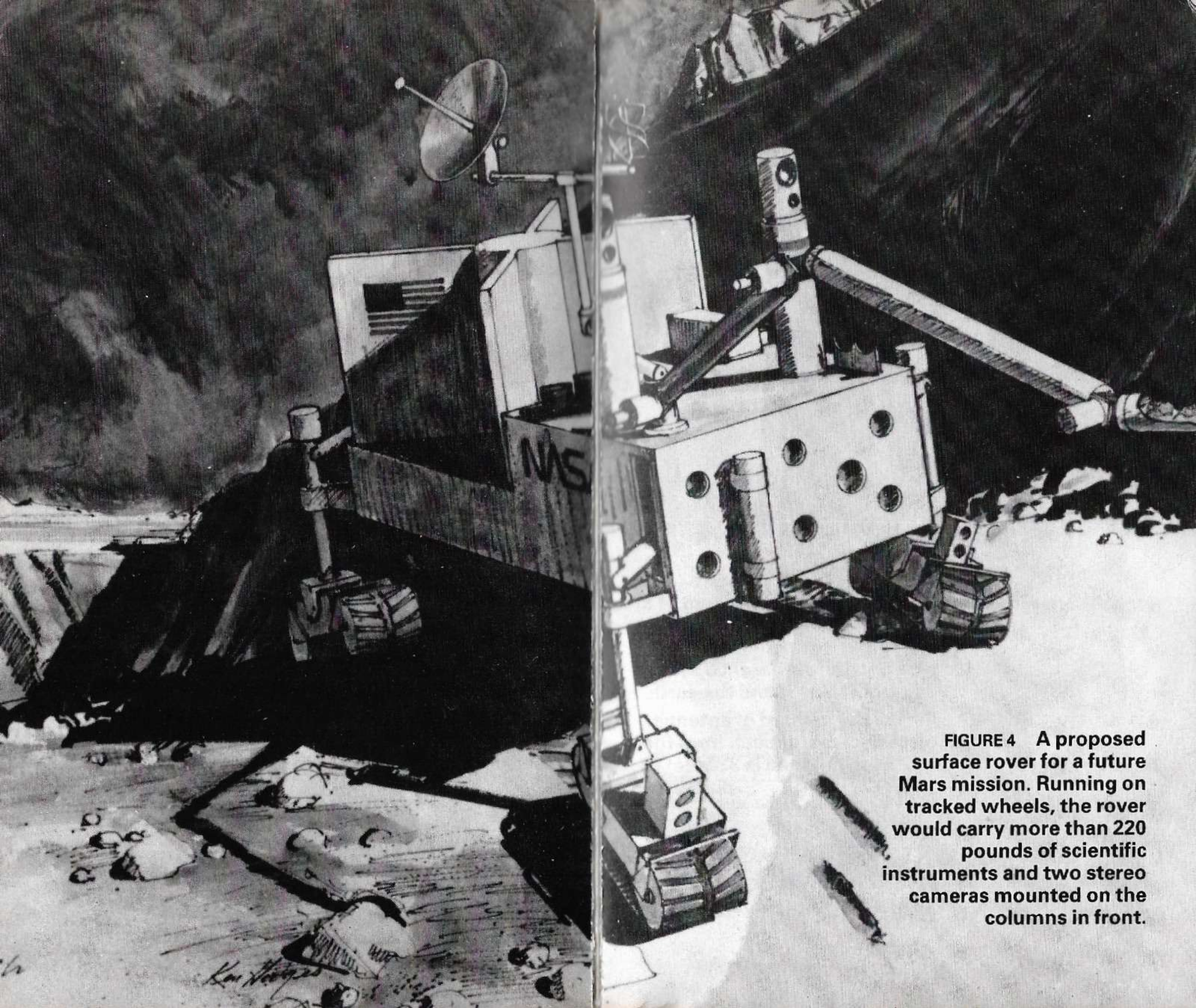


FIGURE 4 A proposed surface rover for a future Mars mission. Running on tracked wheels, the rover would carry more than 220 pounds of scientific instruments and two stereo cameras mounted on the columns in front.

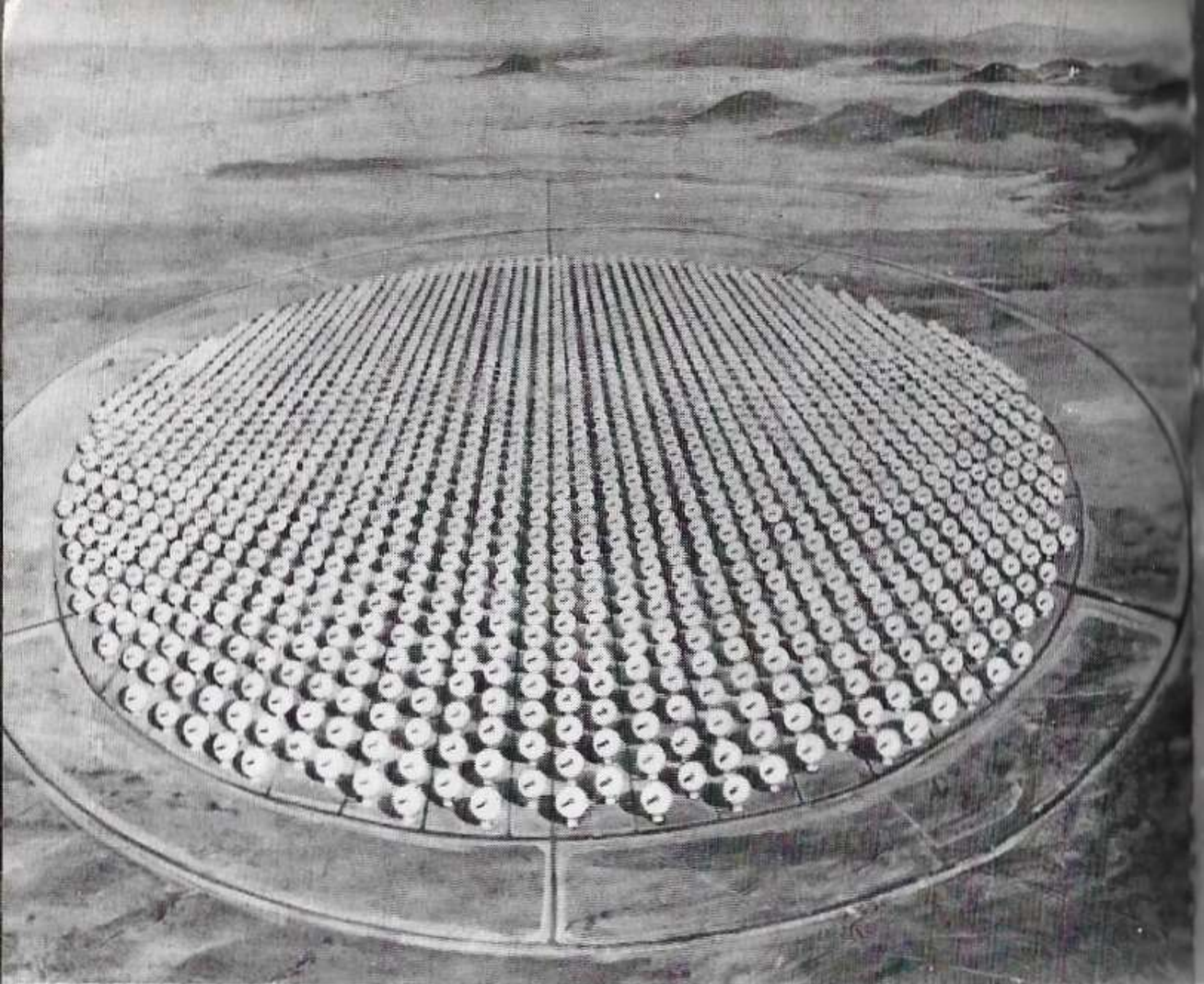
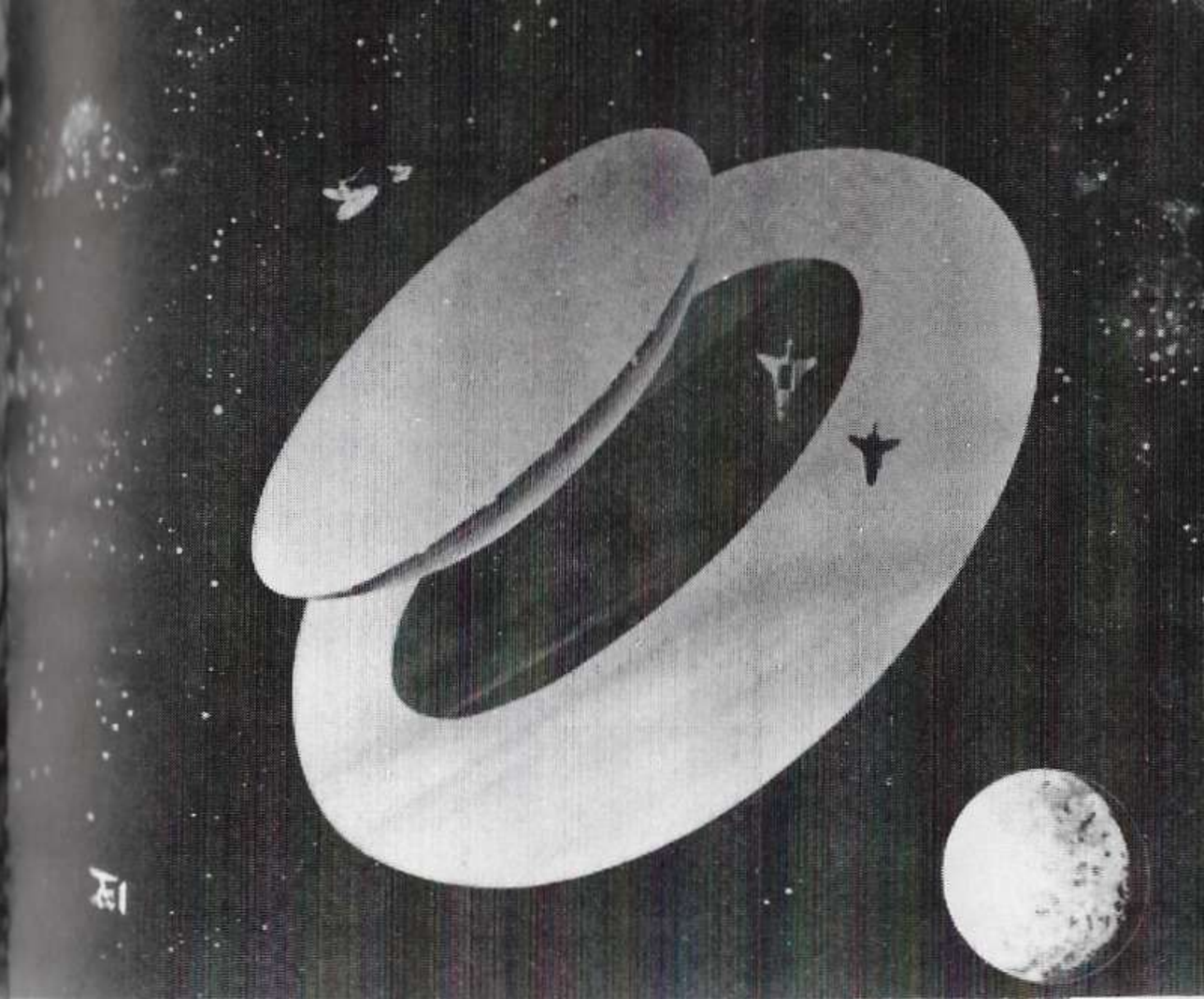
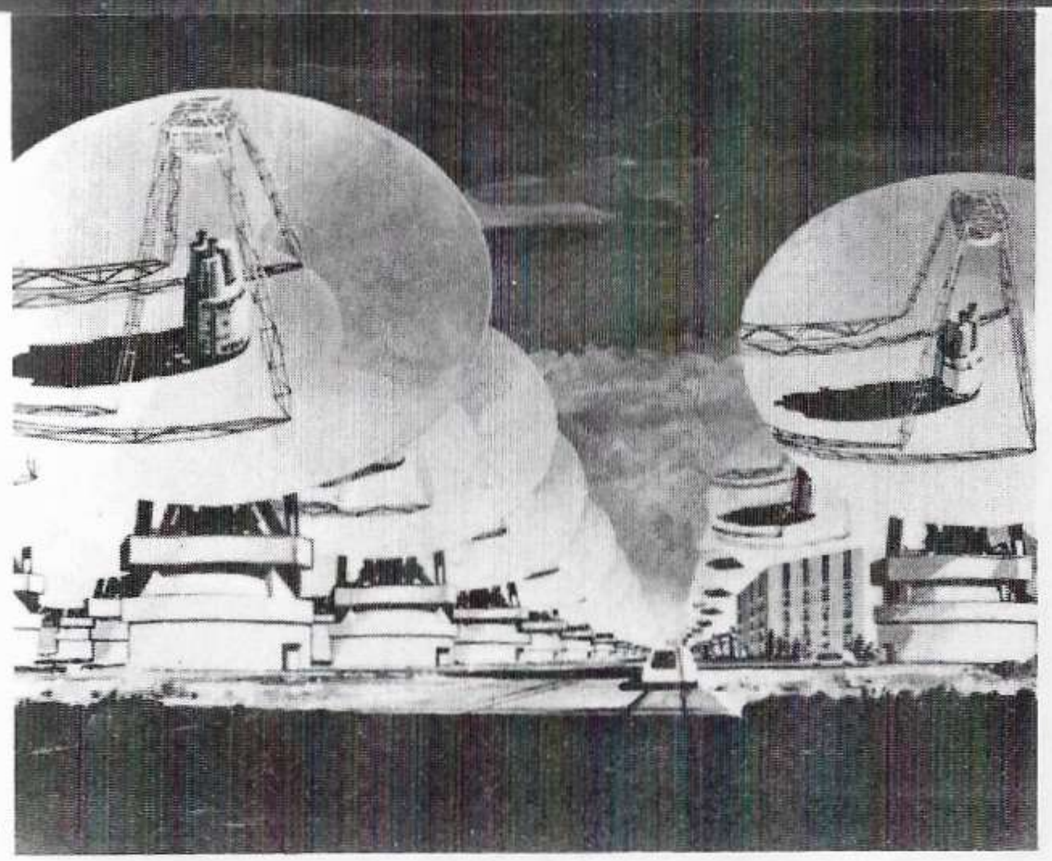


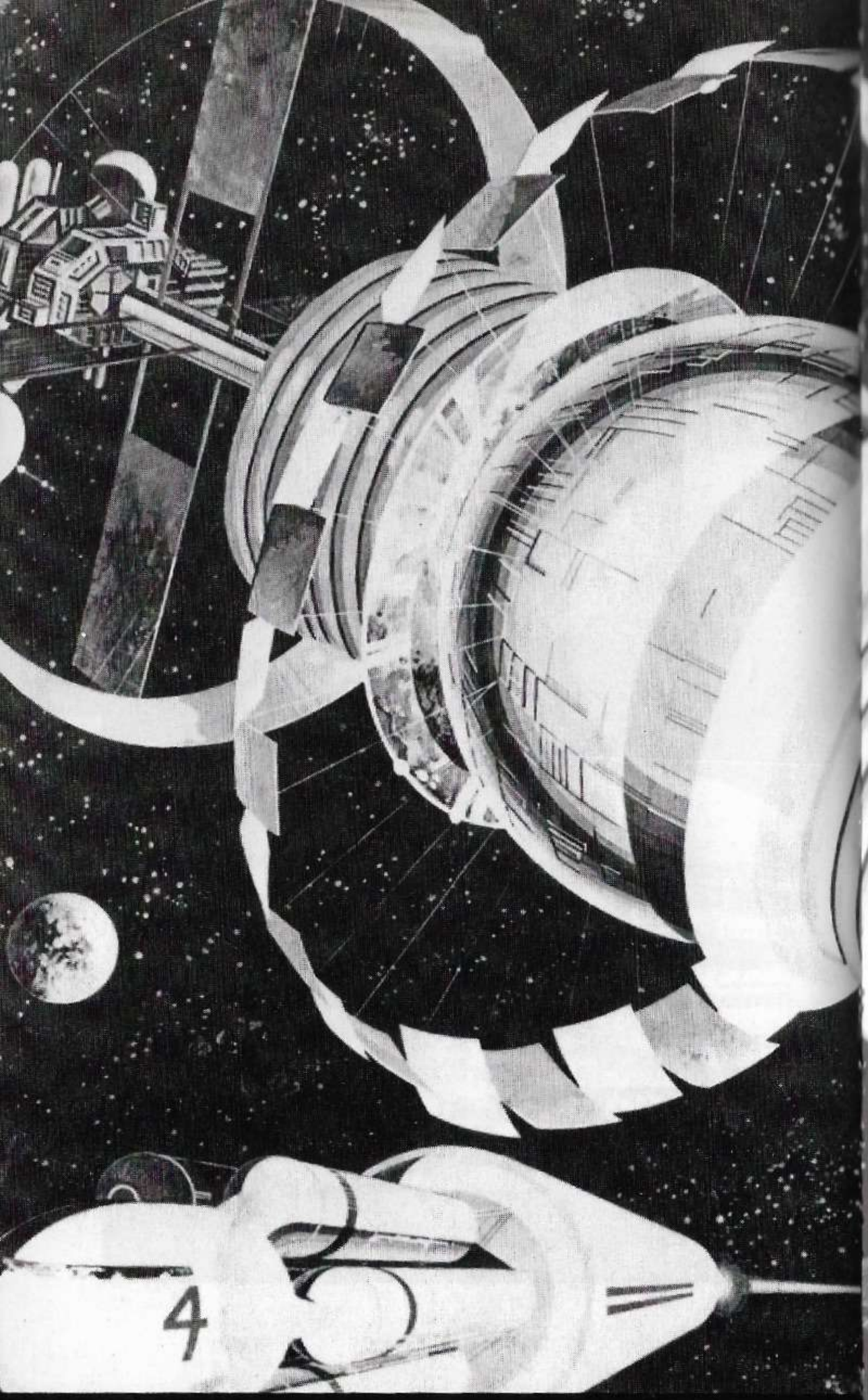
FIGURE 5 Cyclops as seen from the air.

FIGURE 6 An artist's concept of a relatively small SETI system in space. The 1,000-foot-diameter antenna is shielded from radio interference by the disc between it and the earth.

FIGURE 7 Part of the orchard of antennas of Project Cyclops, as seen from the ground. Each antenna is 330 feet in diameter.







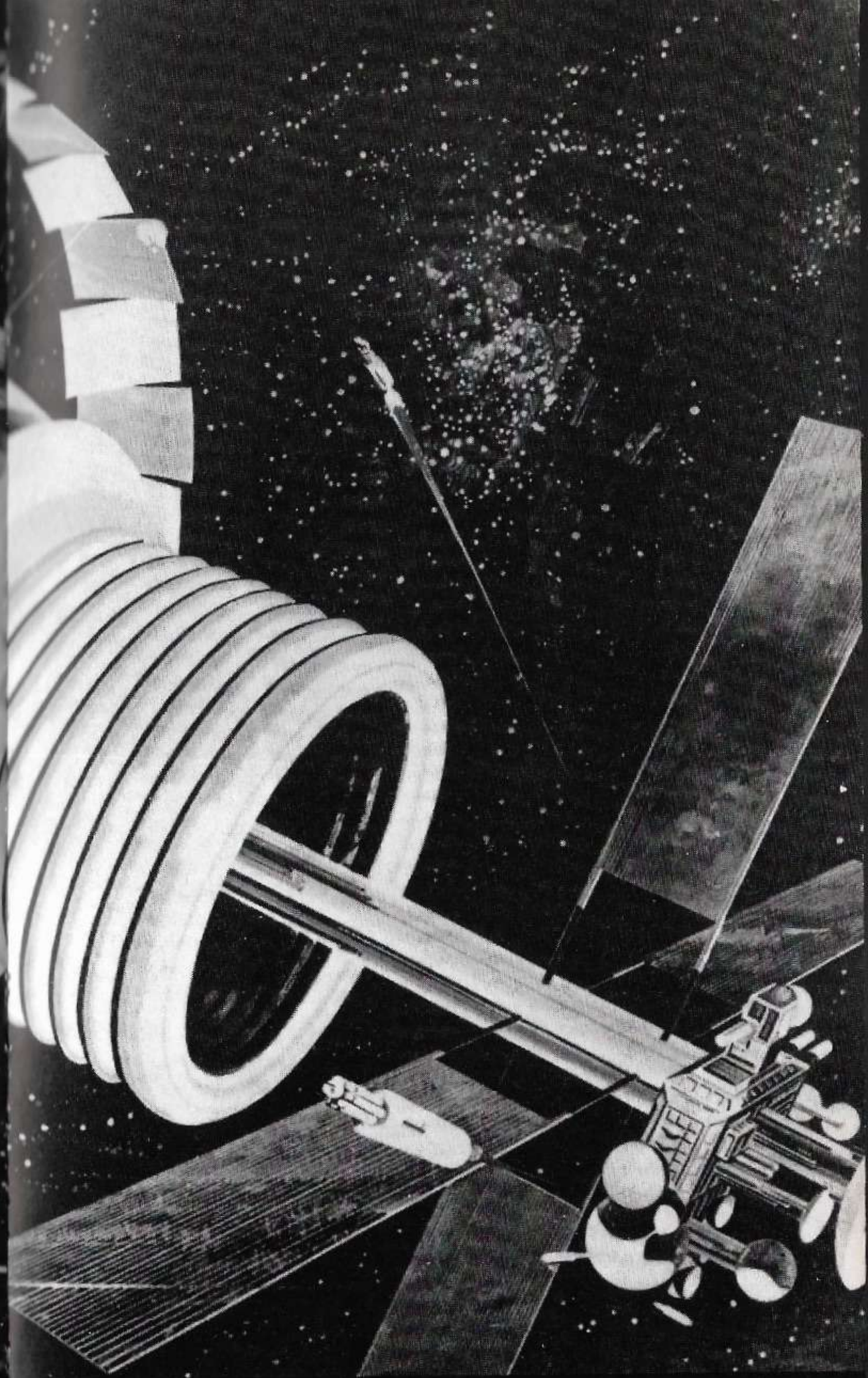


FIGURE 8 A Bernal sphere that could house 10,000 people in a space colony, as envisioned by Gerard K. O'Neill.

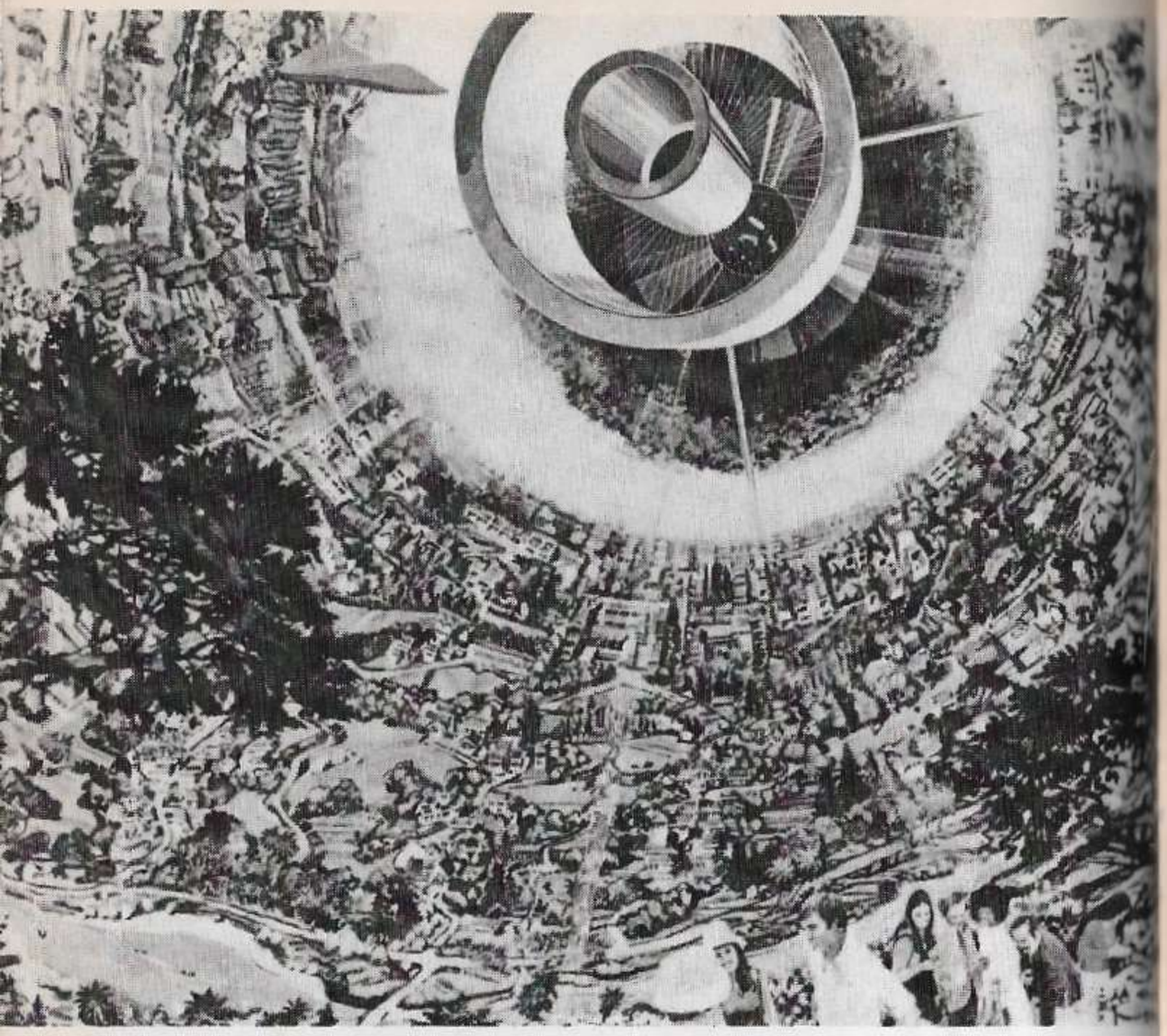


FIGURE 9 The interior of a proposed space colony. Earth-like gravitational pull is provided by spinning the colony slowly. The corridor in the centre has zero gravity and leads to industrial areas, farms, and other facilities.

the bomber's crew were a meteorite, the star Vega, and the lights of a commercial airliner landing at Dallas Airport.

UFO believers have two reactions to Klass's debunking efforts: either they ignore them (the McMinnville case and the RB-47 incident show up regularly in new UFO books as unexplained sightings) or they substitute other sighting reports. There are always plenty of other reports; Klass himself acknowledges that in the time that it takes him to investigate one case, a dozen or more will be discovered by ufologists. His response to the ufologists is to put his money where his mouth is. Klass has offered to buy back every copy of his book, *UFOs Explained* at its list price of $8.95 'if at any time evidence of an authentic extraterrestrial spaceship is ever found'. He also has a standing offer if anyone agrees to pay him $100 a year for ten years, Klass promises to pay $10,000 if UFOs are proven to come from an extraterrestrial civilisation. As of 1977, he had two takers for the $10,000 bet. Most ufologists seem to agree with James Lorenzen of APRO, who told one interviewer that Klass's offer is 'a tricky and devious proposition which typifies his whole approach to the UFO problem'.

The Chariots of Von Däniken

Klass has his hands so full with current UFO reports that he has never taken on one of the most successful offshoots of the subject: Erich von Däniken and his prehistoric visitors from extraterrestrial civilisations. Von Däniken has been remarkably successful, at least with general readers. His first book, *Chariots of the Gods?* published in 1969, sold millions of copies in Europe and here. His next book, *Gods from Outer Space*, and its successors continued the best-selling record. Indeed, von Däniken seems to have started a publishing industry. Any paperback store features a shelf-ful of books dedicated to the proposition that extraterrestrial visitors were here thousands of years ago and that they played an important role in (depending on the tack of the author) either starting life on earth or establishing civilisation here.

Von Däniken's success puzzles many scientists who maintain that he is neither original nor very imaginative. In the early decades of the century, an eccentric American writer named Charles Fort proposed that extraterrestrial beings had visited the earth – indeed, that earthlings were unwitting property of powerful, unseen beings. Fort's books never had a fraction of the success

that von Däniken has achieved, but Fort was there first with the idea.

In addition, scientists who have read von Däniken's books say that there is hardly a correct idea in any of them. They accuse von Däniken of naïvité, at the very least. It has been pointed out that one of von Däniken's basic methods has been the systematic underestimation of the technical ability of early civilisations. For example, von Däniken says that the natives of Easter Island could never have carved the huge statues that dot the island. He supports that belief with a report of his own failure in trying to carve this island's volcanic rock, and concludes that only 'alien visitors' could have supplied the islanders with the 'sophisticated technical tools' needed to make the statues.

However, anthropologists familiar with the Pacific say that many Polynesian peoples carve large funerary statues. On most islands, the carvings are of wood. Easter Island is almost treeless, but it has an ample supply of volcanic rock. Instead of being evidence of alien visitations, the Easter Island statues thus are just one example of a common local activity.

A few critics have tracked down von Däniken's interpretations, one by one. Where he marvels at engravings of rocket-like machines in early China, others point out that the Chinese shot off rockets in festive celebrations. Where he expresses amazement that drawings from primitive South America show camels and lions that did not exist on the continent, others point out that llamas and pumas did. Looking at a carving in the Mayan site of Palenque, in what is now Mexico, von Däniken sees a man dressed in tight pants and socks, sitting at the controls of a spaceship. Anthropologists see a man wearing a conventional Mayan loincloth and head-dress and lying on a sacrificial altar – a common theme in Mayan art.

Often, very little detective work is needed to refute one of von Däniken's ideas. In *Chariots of the Gods?*, for example, he heaps scorn on the thought that the ancient Egyptians could have built the pyramids some 4500 years ago without extraterrestrial help. They simply could not have moved the massive blocks of stone of which the pyramids are made, von Däniken said, unless visitors from space gave them assistance. He scoffs at the belief that the stone blocks were moved on wooden rollers and were pulled by ropes. Von Däniken says bluntly that the Egyptians did not have trees from which to make rollers and that they did not know of rope.

Egyptologists don't know where von Däniken gets his in-

formation. They point out that there are ample records of a timber trade which brought cedars from Lebanon in large quantity. As for rope, archaeologists have more than pictures of rope being used by the ancient Egyptians; they have some of the actual rope, including samples found in the quarries from which the stones of the pyramids were taken.

Similar examples of far-fetched conclusions from the writings of von Däniken and others of his school are almost endless. Nevertheless, their books sell marvellously well, while the demand for sceptical writings is minimal. Those scientists who have taken the time to study the subject often explain the success of such books as a response to the gap that the decline of religious beliefs has left on our lives.

Religious belief was once a unifying factor in society. Science, which has done so much to undermine religion, and which has made life more difficult by substituting constant change for old-time stability, offers no comforting substitutes for the old verities. Pseudo-science does. The 'little green men' who step out of UFOs usually have messages of comfort for mankind. The ancient visitors of von Däniken are powerful beings who descend from the sky to offer help to a bewildered human race. Once again, Someone Up There is watching over us. UFOs, present or past, offer a scientific basis for faith and hope.

The Response of Astronomy

Unfortunately, the hard numbers of astronomy do not provide much support for believing that UFOs are extraterrestrial visitors. There are three problems in accepting the extraterrestrial hypothesis of UFOs: the galaxy is very large, it is very old, and the cost of interstellar travel is very high.

Assume that there are a million civilisations in the galaxy, and that all of them are capable of interstellar travel. Assume that all of these civilisations are both willing and able to explore the galaxy systematically. There are about 100 billion stars in the galaxy, and about 10 billion of them are candidates for planetary systems that could support life. The sun is one of the 10 billion. Since the sun does not seem to be unusual in any way, it probably would not be high on the list of priorities of an exploring civilisation; it would have to wait its turn in a methodical search.

If those one million civilisations each launch one starship a year, and if each starship visits one planetary system in a year – both optimistic assumptions – it will take a total of 10,000 years

before one starship visits our planetary system. To put it another way, the earth could expect one visit from a starship every 10,000 years. Or, to put it yet another way, if the earth is visited by only one starship a year, each of the one million exploring civilisations must be launching 10,000 starships a year!

But ufologists are not talking about just one starship visit a year. If even a fraction of the reports that they have collected are true, the earth is being visited by what amounts to a swarm of extraterrestrial spaceships. The sheer number of UFO reports is one reason why people in the SETI community do not believe in them. One is reminded of what Albert Einstein is reported to have said when told that a hundred scientists had signed a statement saying that relatively was wrong. Einstein said: 'If I were wrong, one would be enough.'

One sound, indisputable case would be enough to establish the extraterrestrial origin of UFOs. In the opinion of just about everyone in the SETI community, there is no such case.

Carl Sagan, a leading spokesman for SETI, always says the same thing on those frequent occasions when he is asked about UFOs: there are no cases that are simultaneously reliable – meaning that the object has been seen by a large number of good witnesses – and exotic, meaning that it cannot be explained by ordinary means. And Sagan can certainly not be accused either of narrowness or of lack of imagination. Indeed, his willingness to entertain imaginative ideas about extraterrestrial life is well known.

Another reason why people in the SETI community are non-believers in UFOs is their knowledge about the nature of interstellar travel. As we shall see shortly, travelling between stars is an expensive, long-range effort. If an alien spaceship arrived on earth, it would have come a very long distance. It will also be making a rare discovery; on the average, it will have visited 9999 other stars without success, if our earlier calculations are correct. Extraterrestrial visitors could thus be expected to make every effort to establish contact quickly with the scientific and political leaders of the earth. But if the ufologists are right, the starships that have come so far to make contact have been flying around earth aimlessly for several decades, making themselves known to everyone but a qualified scientist or political leader. Loggers, housewives, blue-collar workmen – all have been contacted (if the UFO stories are true) and have even been aboard extraterrestrial ships, but nothing has been done to carry out what must be the main mission of any interstellar visit.

In short, UFOs simply do not make sense to the people in the SETI community. 'To be quite truthful,' said John Billingham of the Ames Research Center, 'we do not pay significant attention to the UFO issue at all. We feel that the whole area is so debatable, uncertain, and unscientific that it is probably not going to help anybody very much. We don't do anything on UFOs, and we do not recommend that anybody else do anything on them.'

Nevertheless, public interest does keep the issue alive. The best example of that phenomenon is the success of *Close Encounters of the Third Kind*, a science-fiction film whose concluding scene is a meeting between earth's scientists and a huge spaceship carrying (literally) little green men.

The movie was released, with the usual publicity building, late in 1977. A few months earlier, Philip Klass was predicting that there would be a new wave of UFO sightings that would coincide with the release of the film. That wave – a 'UFO flap' – came along right on schedule. Less predictably, the rising interest in UFOs brought a request from the White House for a new NASA investigation of UFOs. (Before he became president, Jimmy Carter saw a UFO. Scientists who have studied his report are satisfied that he saw the planet Venus.) In addition, there was a report in the magazine *US News and World Report* early in 1977 saying that the government was about to open its secret files to publish some previously restricted information on UFOs. Finally, Sir Eric Gairy, the prime minister of Grenada, made one of his periodic appeals to the United Nations on 7 October 1977, for creation of a UN body to study the UFO question.

Nothing came of all of this. As for secret information in government files, Frank Press, President Carter's science adviser, was told by both the Central Intelligence Agency and the Air Force that there wasn't any. In the UN, Gairy spoke to a bored General Assembly, most of whose members had walked out by the time he finished. No one bothered to respond, and a draft resolution on UFOs drew almost no reaction. The White House request to NASA prompted a press release in which the space agency said that its scientists would 'keep an open mind and maintain our scientific curiosity and a willingness to analyse technical problems within our competence', but said that:

> There is an absence of tangible evidence available for thorough laboratory analysis and because of the absence of such evidence

> we have not been able to devise a sound scientific procedure to investigate the phenomenon. To proceed on a research task without a disciplinary framework or an exploratory technique in mind to find ways in which this problem can be studied would be wasteful and unproductive . . . I would therefore propose that NASA take no steps to establish a research activity in this area . . .

Despite such blunt words, the UFO phenomenon rolls along briskly outside the scientific community. Hynek's books enjoyed a surge in sales, and Hynek himself was a frequent visitor to television talk shows. More people kept seeing flying objects. An organisation called Ground Saucer Watch, Inc, sued the CIA for release of all the agency's secret records on UFOs. And the success of *Close Encounters of the Third Kind* and another science fiction film, *Star Wars*, started a wave of science fiction in Hollywood. The feeling that something important was just around the corner remained alive in ufology, as it has been for decades. And as it probably will be for many more decades.

CHAPTER EIGHT

Travelling

People in SETI can be divided into two groups: listeners and travellers. Listeners believe that interstellar travel is so difficult and costly that the only practical method of contacting an extraterrestrial civilisation is by using radio messages. Travellers believe that voyages between stars are practical for advanced civilisations. Travellers are in the minority.

The itinerary of Pioneer 10, a spacecraft that is now travelling through the solar system, helps illustrate the reason for doubt about the ability of earth to make physical contact with beings on a planet orbiting another star. Pioneer 10 was launched from earth on a mission to explore the region of space near Jupiter in March 1972. It arrived at Jupiter in December 1973. Travelling at a speed of 35,000 miles per hour, it will not leave the solar system until the 1980s. (Pioneer 11, launched a year later than its sister ship, was targeted for a 1979 rendezvous with Saturn after its 1974 encounter with Jupiter.) Pioneer 10 carries a plaque designed to inform inhabitants of other planets that intelligent

life exists on earth, and to enable such beings to locate earth. At its present rate of speed, Pioneer 10 will arrive at the distance of the nearest star at AD 80,000. Its projected interstellar travel time is thus many millennia longer than civilisation has existed on earth. Those who sent the message aboard Pioneer 10 have no expectation at all of being alive when and if an answer is received.

Interstellar Voyages: A Question of Propulsion

The two Pioneer spacecraft were launched with chemical rockets, the only kind that the human race has thus far used to launch spacecraft. Less patience on the part of senders of an interstellar message is needed if more powerful methods of propulsion are used. One such method is the use of thermonuclear bombs, which got fairly serious consideration in the 1960s under the name of Project Orion. The principle is simple: bombs would be expelled from the rear of a spacecraft and would explode. The force of the explosions would accelerate the spacecraft. Repeated explosions would propel the spacecraft at a reasonable fraction of the speed of light.

Freeman J. Dyson, a theoretical physicist at the Institute for Advanced Study in Princeton, New Jersey, and the source of many provocative ideas in SETI, has calculated that an interstellar voyage could be made by a spacecraft that started out with 30,000 hydrogen bombs. If one bomb were exploded every second for three days, Dyson calculates, the spacecraft would achieve a speed of about 3 per cent the speed of light. The shock to the crew of the spacecraft would be absorbed by a giant plate mounted at the rear of the craft. When all the bombs were exploded, the spacecraft would have lost six-sevenths of its original mass. It would arrive at Alpha Centauri, a binary star system that is the sun's nearest stellar neighbour, 4.3 light-years distant, in about 130 years.

Several problems present themselves. When the spacecraft arrived at Alpha Centauri, it would be travelling at a speed of more than 5500 miles per second, which would not be ideal for detailed observation of the star system. To slow the spacecraft or to turn it back towards earth would require another large investment in hydrogen bombs. These bombs would have to be carried all the way from earth and would represent a large fraction of the spacecraft's payload. The trip would not be cheap.

Members of the crew would have to be a special kind of people. The most likely possibility they face is a lifetime aboard the interstellar spacecraft, with the hope that their children or grandchildren would see Alpha Centauri up close. A spacecraft that set out on a journey of more than a century would have to be of an unusual design. It could not meet the needs of its passengers by ordinary stores. Instead, it would have to be large enough to contain a complete ecological community whose flora and fauna could sustain a life-to-death cycle for generations. As early as 1929, J. D. Bernal envisioned such a 'space ark' setting off on an interstellar voyage. Those who boarded the ark as it cast off from earth would be aware that they would never see their native planet again. They would also be aware that they were entrusting their lives to a machine that would have to maintain near-perfect functioning for many decades, far longer than any machine of comparable complexity has operated. The psychology of such an interstellar exploratory trip is interesting in the extreme.

Hydrogen bombs are not necessary for an interstellar trip, according to some studies. The British Planetary Society has a concept called Project Daedalus, in which an interstellar probe with a 500-ton payload would travel to Barnard's star. The starting weight of the probe would be 68,620 tons, most of which would be fuel consisting of small pellets of deuterium (an isotope of hydrogen whose nucleus consists of one proton and one neutron) and helium-3 (two protons, one neutron). The pellets would be fired into a strong magnetic field at the rate of 250 times a second. There they would be heated and compressed by electron beams that would cause them to fuse, releasing enormous amounts of energy. A 400-foot shell would absorb the energy to propel the spacecraft at a velocity that would eventually be 14 per cent of the speed of light.

The 5.9-light-year journey to Barnard's star would take 47 years in such a spacecraft. The spacecraft would fly by Barnard's star in less than 10 hours, releasing 10 or 20 probes as it passed. Messages from those probes, describing the environment near Barnard's star, would be received on earth nearly six years later. The mother ship would hurtle into the galaxy, lost to earth forever.

A comparable interstellar spacecraft project that leaves open the possiblity of a return to earth was described in 1964 by Robert D. Enzmann of the Raytheon Corporation. The Enzmann spacecraft would be a huge, strange device: a cylinder 300 feet in diameter and 1000 feet long, with a ball of frozen deuterium 1000 feet in diameter at one end. The deuterium would not only serve as fuel for the fusion engines, but would also provide protection against radiation from the engine. The spacecraft would set off with a complement of 200 and would have room for 2000 assuming a steady growth in population during the trip. A return voyage would be possible if the spacecraft could replenish its supply of deuterium on arrival in a new planetary system. Enzmann's 'flying iceberg' would be able to accelerate to 10 per cent of the speed of light and would reach Alpha Centauri in slightly more than 50 years.

These numbers are not regarded with happiness by the 'listeners' in SETI. A fifty-year one-way flight would require special measures, many of which are only theoretically possible at the current state of scientific knowledge. The simplest concept – the 'space ark' – would require the creation of a fully balanced ecological community that could survive without outside help in the hostile environment of space for decades. No such closed system has been produced by mankind.

Another proposal provides a standard spacecraft environment, but suggests genetic engineering or similarly advanced biological techniques to slow down the metabolic requirements of the crew, reducing their demand for food, water, and air. The science fiction movie *2001, A Space Odyssey*, had such a plot device. Even though the spacecraft of the film had a mission that kept it within the solar system, most of its crew members were put into hibernation – suspended animation – for the trip. In the film, they were done in by the deranged master computer, HAL, which was deactivated by the survivors. Suspended animation for interstellar travel is still a movie concept.

Rather than fooling around with half-way measures such as suspended animation and fusion-powered interstellar probes, some SETI theorists prefer to demonstrate the difficulty of interstellar travel by leaping to the outermost limits of current concepts. As far as is known, the best rocket that physical law will allow is the photon rocket, which converts matter into energy

with 100 per cent efficiency. (By contrast, fusion power converts only 0.4 per cent of matter into energy.)

The fuel for a photon rocket would consist of equal amounts of matter and antimatter, which annihilate each other on contact and flash into photons. It has been calculated that a photon rocketship could make a round trip from earth to Alpha Centauri in about ten years. The takeoff weight of the spacecraft would be 34,000 tons, of which 33,000 tons would be fuel. A recent NASA study estimated the cost of the fuel for one voyage at $100 million billion and added: 'To discover life we might have to make many thousands of such sorties.'

Cost is only one problem of the photon engine. A large quantity of heat would be released by the matter-antimatter reaction. The NASA study set the initial power of the engine at a billion billion watts. If only a millionth part of this energy were absorbed by the spacecraft, the cooling surface needed to dissipate the excess heat would be about 1000 square miles. The study also noted 'the problem of interstellar dust, each grain of which becomes a miniature atomic bomb when intercepted at nearly optic velocity'. (Optic velocity is the speed of light.)

Of Lasers, 'Ramjets', and 'Hyperspace'

There are other proposals for interstellar travel. One is to use powerful earth-based lasers to push spacecraft along. Lasers emit light of an unusual kind. Light consists of waves. The light from an ordinary lamp or from the sun consists of a mixture of waves of different lengths. A laser emits light of one wavelength. Laser light is thus much more powerfully focused than ordinary light. The theory is that a laser could be focused on a spacecraft, which would be propelled by the energy in the light beam. There is nothing wrong with the theory. However, such a spacecraft would require a laser that is much more powerful than anything yet conceived – let alone built – on earth. If planetary exploration is the objective, lasers of equal power would have to be available at the other end of the journey to slow down the spacecraft. A laser-propelled spacecraft might be a possibility in the distant future; today it is only a concept.

Another concept that has attracted a good deal of attention is the interstellar ramjet, which was proposed in 1960 by engineer Robert W. Bussard. A ramjet is a jet engine that compresses air by the force of its forward motion, then expels the air to produce thrust. An interstellar ramjet would be fuelled by gathering in the

thin mist of hydrogen that is found in outer space, between stars. As Bussard envisioned it, the interstellar ramjet would first be accelerated to a high speed by conventional means, such as ordinary chemical rockets of the kind used today. At that time, the ramjet would take over. It would scoop in the interstellar gas and compress it to the point where the hydrogen atoms would fuse. This fusion energy would produce a high-velocity exhaust that would drive the spacecraft. Bussard calculated that an interstellar ramjet could achieve a steady acceleration of 1 g – that is, about the gravitational pull of earth. Such an acceleration would enable the spacecraft to reach a velocity near the speed of light in a matter of months.

The speed of light is a desirable objective for the design of an interstellar spacecraft. A ship travelling nearly the speed of light could travel to nearby stars in time periods now proposed for manned flights within the solar system. Alpha Centauri would be about four years away, Barnard's star about six years away (double those times for round trips). Neither a space ark nor suspended animation would be needed for such journeys.

However, there is a difficulty with Bussard's interstellar ramjet. It is easy to propose but difficult to build. Hydrogen is not plentiful, by terrestrial standards, in outer space, so a large scoop would have to be built to get enough of it to fuel the spacecraft. Bussard calculated that in regions where interstellar hydrogen is relatively dense by outer-space standards, a scoop more than 60 miles in diameter would be needed for a 1000-ton ship. The combination of light weight and large area for the scoop creates problems. A scoop of that diameter built of mylar plastic one mil thick would weigh 250,000 tons. The need to build such a scoop could be avoided by using a magnetic field to gather the hydrogen, but there is no clear idea of how to produce a field of that size. Bussard's original proposal acknowledged that the fusion reactor needed for the ramjet spacecraft is beyond present capabilities. So is the spacecraft's propulsion system. But he had a hopeful note: 'There is likewise no reason to assume that such a device is forever impossible.'

But the listeners in SETI say that such a spacecraft would pose serious problems even if the scoop, the fusion reactor, and the propulsion system could be built. For example, how is the spacecraft to be decelerated when it arrives at its target star? The ramjet has no brakes, and turning it around would not be easy. And as the spacecraft accelerates towards the speed of light, the stars towards which it is heading will start to disappear as the

motion of the ship shifts their light towards shorter wavelengths As it gets close to the speed of light, the spacecraft will have to be piloted by a crew that is looking into a growing circle of blackness dead ahead. Finally, to a spacecraft travelling at great speeds, grains of space dust and interstellar gases are high-speed missiles capable of doing damage.

As outlandish as the interstellar ramjet may seem, there are even more speculative proposals for interstellar travel. One of them is to first discover a passage through 'hyperspace', a theoretical passageway through another dimension that would enable a spacecraft to overcome the speed-of-light barrier. Another scheme would convert both spacecraft and crew into some form of radiant energy, transmit the energy to distant stars and then reassemble the energy into matter, more or less in the way that telephone messages now are transmitted, or the way the 'Star Trek' crew is beamed up and down from the *Enterprise*. Yet another theory is that interstellar travel might be possible using tachyons: postulated particles that travel faster than light. However, the existence of tachyons is still highly speculative.

Is Interstellar Flight 'Out of the Question'?

Looking over the list of proposals for interstellar travel helps one to understand why the listeners are dominant in SETI today. At least two NASA reports on SETI, prepared by committees on which listeners predominated, contained the same conclusion, word for word, on interstellar travel:

> A sober appraisal of all the methods so far proposed forces one to the conclusion that interstellar flight is out of the question not only for the present but also for an indefinitely long time in the future. It is not a physical impossibility but it is an economic impossibility at the present time. Some unforeseeable breakthroughs must occur before man can physically travel to the stars.

Nevertheless, pockets of traveller sentiment exist within the SETI community. One traveller is Ronald Bracewell of Stanford University. Just as listeners believe that interstellar travel is impractical now, Bracewell believes that listening for signals from an extraterrestrial civilisation is impractical for three reasons: a listening programme will cost too much, it will take too much time to be acceptable to political leaders, and it has an unacceptably low chance of succeeding unless the universe is rather

thickly packed with advanced civilisations. Bracewell has said that contact with another civilisation will probably be established not by sending radio waves, nor by sending manned spacecraft, but rather by the use of unmanned interstellar probes.

Sending Unmanned Probes to a 'Likely Star'

Just as we have sent unmanned probes to Jupiter and to Mars, Bracewell says, the time will come when we send unmanned probes to the stars. As is common in SETI, Bracewell assumed uninterrupted technological growth. He anticipates that terrestrial scientists will someday have the ability not only to send spacecraft to the vicinity of a 'likely star', but also to put the probe into orbit in the star's habitable zone and to have it seek out a likely planet in the life zone. If the planet has no advanced life, the probe can fulfil a scientific function by making the same sort of measurements as Viking made of Mars. If there is a technological civilisation on the planet, the probe can establish contact and begin a dialogue between civilisations.

How could the probe make contact? Bracewell favours a method that is brilliantly simple. It requires no more than an ordinary radio or television receiver hooked up to an inexpensive transmitter. When the probe detected a radio television message from the planet, it would wait a few seconds and then start transmitting the same message. For example, if the probe happened to tune in on a classical music station that was broadcasting Beethoven's Fifth Symphony, it would transmit the music with a time lag of ten or fifteen seconds. The time lag would be selected to distinguish it from all known natural causes of repeat signals, such as radio echoes from the ionosphere, the band of charged particles in the earth's upper atmosphere.

If the first transmission did not elicit a response, the probe would try the same tactic on another frequency. Sooner or later, Bracewell believes, engineers and scientists on the planet are bound to recognise the nature of the signal and to work out the orbit of the probe. At that point, the interstellar messenger would be programmed to (a) inform its home planet that contact with an advanced civilisation had been made and (b) open a cautious dialogue leading to a fully fledged exchange of information that would allow the two home planets to make direct contact. (The opening phase of the dialogue would have to be cautious to avoid blundering intervention into a delicate international situation of the sort that now exists on earth.) For example, the

probe could carry a computer whose memory would contain television or radio messages that would give its home planet's position, describe the planet's inhabitants and their language, and give instructions on the best way to make direct planet-to-planet contact.

If the universe has a fairly large population of technical civilisations, Bracewell says, such interstellar probes would not be necessary because advanced civilisations would be less than thirty light-years apart and could easily detect each other by using radio telescopes. Probes do make sense if advanced civilisations are rare enough so that the distance between them is more than thirty light-years. If L, the lifetime of an advanced civilisation, is very large, it is quite possible that an interstellar probe is on the way to the solar system or has already arrived. 'One might be in our system now, and if this is the case, we should be very careful not to overlook unexplained radio signals that may be received,' Bracewell said in a 1962 lecture.

An Interstellar SOS?

One curious episode in SETI is based on the theory that signals from an interstellar probe have already been received on earth. The story, which has had much more attention in Great Britain than in the United States, began in 1927, when a Dutch engineer named Balthasar Van der Pol began picking up strange echoes from an experimental shortwave radio transmitter at Eindhoven. Word of the echoes found their way to a Swedish scientist, Carl Störmer, who arranged for a series of experiments using the transmitter. The original echoes had come back with a three-second delay and were interpreted as reflections from the moon. Starting in October 1928, a station in Oslo began picking up echoes with time delays varying from three to fifteen seconds. Thirteen days later, another series of echoes, with time delays ranging from three to thirty seconds, were received.

The matter was allowed to drop until the early 1970s, when it was picked up by Duncan Lunan, a Scottish writer and SETI enthusiast. Lunan has written a book describing his interpretation of the signals. In it Lunan says, 'Assuming for the sake of argument that the echo patterns came from a space probe, therefore, I asked, "What meaning could these signals be meant to convey?" '

Strongly influenced by Bracewell's theories, Lunan was able to establish to his own satisfaction that the time delays in the

signals did indeed bear a message, and one of impressive complexity. In 1973 he announced that the time sequence of the signals could be interpreted as a star map of the constellation Boötis, which includes the bright star Arcturus. The fact that Arcturus was slightly misplaced in the star map only added weight to the interpretation, Lunan said. He calculated that Arcturus had been in that position several thousand years ago, when a space probe might have been launched by an extra-terrestrial civilisation.

In his writings and lectures, Lunan says that his study of the original LDEs (long-delayed echoes) and of others that have occurred more recently indicates that earth has received a message from the star system Epsilon Boötis. As Lunan reads the message, it tells us that there are seven planets orbiting Epsilon Boötis, that the senders of the message originally lived on the second planet and that they have had to move to the sixth planet because their star is growing old and is starting to expand. In effect, Lunan said, earth has received an interstellar SOS message from an advanced civilisation in its death throes.

'Travellers' are more common in British SETI circles than in the United States (members of the British Interplanetary Society have a fondness for drawing up plans of hypothetical starships), but Lunan's interpretation of the LDEs seemed to many listeners to be something best approached cautiously. A British electronics engineer, Anthony Lawton, thereupon set about an investigation of LDEs. Lawton not only began transmitting signals to re-create LDEs but also went back to the original Van der Pol work. Lawton's experiments and analysis, done with the help of a friend, Sidney Newton, have convinced him and most other scientists that LDEs are of natural origin.

Using his own antenna, Lawton has been able to get long-delayed echoes with delay times of a few seconds. He believes that these and the longer echoes are due to reflection of the original signals from the ionosphere. When a radio wave enters the ionosphere, Lawton explains, it can be both delayed and amplified. This means that a radio wave comes out of the ionosphere a few seconds later than it is expected to and with greater strength. The ionosphere consists of bands of charged particles. The bands change constantly in size and position under the influence of natural factors. Ionospheric bands of different sizes and positions can explain all long-delayed echoes, Lawton says.

The clincher comes from a study of the original 1927 data, which Lawton obtained from R. L. A. Appleton, who did some

work on the signals at the time. Precise measurements of the signals showed that the echoes had not come in exactly even-second intervals, as might be expected if they had been relayed by a space probe. Instead, the intervals worked out to be imprecise timings: 5.1 seconds, 2.3 seconds, and the like. Instead of the crisp, precise transmissions we would expect if aliens were trying to communicate with us, the long-delayed echoes are the smeared-out blurred signals that are typical of natural phenomena. Lawton says that he still believes that an alien probe might be somewhere in the solar system, but he does not believe that long-delayed echoes are signals from such a probe. Indeed, in a book he wrote with journalist Jack Stonely, Lawton concluded that 'long-delayed echoes would be a most cumbersome and unnecessarily confusing way of making contact. Surely the obvious thing a probe would be programmed to do would be to send its *own* signals and make itself as conspicuous as possible.'

The episode of the long-delayed echoes is a notable illustration of the persistent intrusion into SETI of themes that once were the monopoly of science fiction. The willingness to entertain ideas that are beyond the current reach of science and technology is an essential part of SETI; the whole field can be described as a science fiction idea that has gained scientific respectability. Generally, it is the travellers rather than the listeners in SETI who are most open to speculative ideas. Listeners are in the happy position of championing programmes that require little or no advance over current technology and that can be described as cost-conscious. Only the duration and ultimate spending required for listening programmes can make a congressman unhappy. The missions envisioned by travellers, however, require an immediate leap to distant technological advances. As the Pioneer 10 mission shows, today's chemical rockets will not get a traveller very far.

But some travellers argue that the interstellar probe is, over the long run, a more sensible undertaking for SETI than a prolonged effort to detect radio signals from another civilisation. Bracewell maintains that unless technical civilisations are unusually common in the galaxy, listening programmes are not likely to succeed because of many factors: funding bodies on any planet will not be willing to pay for a programme that could run for centuries; the chance that any one civilisation will be sending during the brief period that another civilisation is listening is low; and even if one civilisation listens at the proper time, the other

planet may be broadcasting on a different wavelength, or may be using a means of transmission beyond the capabilities of the first civilisation. 'If one hundred light-years is the distance to the next inhabited community, trying to reach them by radio will present extraordinary difficulties and may be doomed to failure,' Bracewell said in a 1960 lecture.

Travellers vs Listeners

Some travellers maintain that sending interstellar probes and trying to detect messages from them is a more practical technique than listening for radio signals from another planet. In a 1977 paper published by the journal *Science*, T. B. H. Kuiper of the Jet Propulsion Laboratory and M. Morris of Cal Tech started with the assumption that any fairly advanced technical civilisation will be able to achieve interstellar travel at one-tenth the speed of light by using nuclear rockets. 'No fundamentally new physics is being advocated,' they wrote, 'and since no known physical principle states that a deuterium fusion rocket is impossible or unfeasible (it appears to be primarily an engineering task), there is every reason to expect its realisation within the next century or so.'

Kuiper and Morris also maintained that the distances between habitable planets is not 'prohibitively large'. They mention not only the space ark ('space ships of sufficient sophistication to permit several generations to live in circumstances not significantly less comfortable than those encountered in crowded cities') but also suspended animation and the possibility that there are 'intelligent beings having significantly longer lifetimes than ours'. (Other scientists have noted that the distance between habitable planets might be much less towards the centre of the galaxy, where the average distance between stars is not much more than one light-year, than it is in the earth's neighbourhood, a galactic suburb where stars are five or six light-years apart, on average.)

Since interstellar travel is inevitable if an advanced society has a long life, Kuiper and Morris say there are two possibilities to deal with: case (i), in which technological societies that live long enough to colonise space are rare, and case (ii), in which there are several such civilisations. Either way, they say, the likelihood of making contact with a technological civilisation by radio is so low that a long-term listening programme is not advisable.

If case (i) is true, they say, then 'the galaxy is esentially un-

populated and the number of radio contact beacons is negligible'. If almost no one is sending, it would be a waste of time to listen. If case (ii) is true, and one or more advanced civilisations have begun colonising the galaxy using spacecraft travelling at one-tenth the speed of light, the argument against listening is more complex but no less convincing, Kuiper and Morris say.

Assume that an advanced civilisation moves to nearby stars in jumps of 10 light-years, and that the civilisation takes 500 years to consolidate each foothold before making the next journey of 10 light-years. The effective rate of expansion is then great enough so that the civilisation will colonise the entire galaxy in no more than 50 million years, Kuiper and Morris calculate. There are three implications of this theory, they say:

(1) A 'galactic community' would exist, in which one or several civilisations communicate with each other throughout the galaxy, and we are located within the 'sphere of influence' of one or more of these civilisations.
(2) The solar system probably would have been visited.
(3) An advanced civilisation would probably have representatives somewhere in the solar neighbourhood. This encompasses Bracewell's suggestion that an advanced civilisation may already have sent an unmanned probe into our system to contact us when we reach some developmental threshold.

If case (i) is true, listening makes no sense because no one is out there. If case (ii) is true, a large-scale listening programme makes no sense because any technical civilisation is either so close to earth that it is easily detectable using current antennas, or such a civilisation is using 'beacons of a more sophisticated nature (beyond the capability of our technology to detect)', or because the other civilisation already knows we exist and is biding its time – presumably until humans become mature enough to join a truly advanced galactic community. Kuiper and Morris leave open the possibility that UFOs really are extraterrestrial visitors that are monitoring our progress and are making contacts with humans in an unnoticeable way. And, apologising for venturing 'far beyond the realm proper to physics and astronomy', they suggest that the earth has not been colonised by a galactic civilisation for several truly cosmic reasons: either our planet is being maintained as a wildlife preserve, or the other civilisation

has advanced so far technologically that it no longer needs a planetary base, or the biology of earth 'is incompatible with or even hostile to that of the species which dominate our part of the galaxy'.

Listeners vs Travellers

Naturally, the listeners in SETI are not convinced by the arguments of the travellers. John Billingham, a leader among the listeners, pointed out not long after the Kuiper and Morris paper was published that their argument could easily be used to show that interstellar travel is improbable even for advanced civilisations.

Kuiper and Morris are quite right in saying that interstellar travel at one-tenth the speed of light would not be difficult to achieve, even with only a slight advance over existing terrestrial technology, Billingham says. They are also quite right in saying that a civilisation using such a relatively modest (by interstellar standards) mode of travel could spread through the galaxy in a relatively brief period of time (again by interstellar standards). And since the galaxy has been in existence for ten billion years or so, it is also quite probable that a large number of civilisations could have evolved to the point where that kind of space colonisation became possible, Billingham says. Nevertheless, he says, we on earth see no evidence for the existence of such a galactic civilisation.

To Billingham, it is an unavoidable conclusion that no such colonising galactic civilisation exists. If it did, we would know of its existence by now. Therefore it is logical to assume that interstellar travel is not a commonplace occurrence in the galaxy, even after ten billion years of evolution. Since we must assume that many advanced civilisations have existed in the course of those ten billion years, the absence of a galactic colonising civilisation based on interstellar travel indicates that starships will always be rare phenomena, Billingham concludes.

Obviously, this sort of listener-traveller debate could go round and round endlessly. Equally obviously, the listeners have the best of it now for purely practical reasons. Interstellar travel would cost a great deal of money, even at the most modest level imaginable. That kind of money simply is not available. After the United States spent its $25 billion on Project Apollo, there was a quiet backlash against similar space projects. Spiro Agnew, then

vice-president and typically one beat behind, was laughed at when he said the United States should start planning a manned mission to Mars.

The High Cost of Travel

The thought of such a project, which would have cost an estimated $100 billion in the less-inflated dollars of the 1960s, was so alarming that Congress rather quickly cancelled funding for Nerva, a nuclear rocket that would make a manned Mars mission possible. The project was killed even though the nuclear rocket was meeting most of its technical targets on schedule and even though NASA insisted that Nerva would never be used for a trip to Mars. Congress made it clear that cancellation of the nuclear rocket was an insurance policy against a future Mars mission.

For the time being, at least, Congress and the administration still are thinking small about space – 'small' meaning a space budget of about $4 billion a year. By their nature, plans for interstellar travel require thinking big. For example, one proposal for a laser-propelled trip to another star calls for unfurling a sail that would be attached to the starship by cables no less than twenty miles long. Dyson's hydrogen-bomb ship would require 30,000 bombs. Enzmann's 'frozen iceberg' calls for many tons of frozen deuterium. These are not cheap ideas.

In addition to their costs, plans for interstellar spaceships have another drawback: most of them require technology that has not yet been developed. Indeed, several of them require technology of a sort that has not yet been conceived. Travellers thus must think not only big but also long, in terms of at least decades and most likely centuries before their plans can be fulfilled. An early paper on interstellar travel by Carl Sagan summed the field up best. Sagan wrote that 'interstellar spaceflight at relativistic velocities to the furthest reaches of our galaxy is a feasible objective for humanity'. But it is feasible, he said, only given 'a modicum of scientific and technological progress within the next few centuries'.

That time scale should be enough to discourage proposals for interstellar travel now. But there is also another reason why such plans, attractive as they appear on paper, are being discouraged. Interstellar travel is as much in the realm of science fiction as it is in the area of scientific fact. And the search for extraterrestrial intelligence has begun to reach a state of maturity in which science

fiction proposals are an embarrassment. Spokesmen for SETI are presenting carefully drawn plans for their projects to cost-conscious administrators and legislators. Asking for a few million real dollars is far different from drawing up unrealisable billion-dollar projects. In fact, the existence of those unusual projects could endanger the funding for realisable SETI programmes. It is significant that the most imaginative schemes for interstellar travel originate with Britain, whose space programme is minimal when compared to that of the United States. When nothing is possible, anything is imaginable.

Interstellar travel projects are great fun to write about and marvellous stuff to read. One of them might come to fruition after a while. But for those in SETI who are working on more than fun and games right now, listening is the only game in town. Even Kuiper and Morris concluded their paper by recommending a radio-wave frequency at which listening should be done. Listening will be the primary technique of SETI for the years ahead, as it has been since the field was born.

CHAPTER NINE

Listening

In a report that was issued in 1971 to propose a major SETI programme called Project Cyclops, Bernard M. Oliver of the Hewlett-Packard Corporation, one of the leaders in the field, summed up the desirable properties of any particles that could be sent the very long distances needed for interstellar communication:

(1) The energy . . . should be minimised, other things being equal.
(2) The velocity should be as high as possible.
(3) The particle should be easy to generate, launch, and capture.
(4) The particles should not be appreciably absorbed or deflected by the interstellar medium.

All these requirements are met by radio waves. Like visible light and all other kinds of electromagnetic radiation, radio waves can

be regarded as consisting of particles called photons. The advantages of photons for interstellar communication are obvious, Oliver went on:

> Of all known particles, photons are the fastest, easiest to generate in large numbers and to focus and capture. Low-frequency photons are affected very little by the interstellar medium and their energy is very small compared with all other bullets . . . Almost certainly electromagnetic waves of some frequency are the best means of interstellar communication – and our *only* hope at the present time.

That last sentence expresses the opinion of almost everybody in the SETI community now. In the abstract, some travellers believe that the earth ultimately will have to send space probes to other stars. But even the more optimistic travellers are prepared to wait decades before the first interstellar probes are launched. To launch such probes, we would need not only billions of dollars, but also some major technological advances. In the world of here and now, no one is disputing the statement that radio waves are 'our only hope at the present time'.

'Our Only Hope at the Present Time'

Put in such terms, the travelling-vs-listening debate is easy to resolve. Either earth attempts to send, as Oliver says, 'tons of metal' over distances of many light-years, or we transmit (or receive) information in the form of radio waves. Since earth already is well equipped with antennas that can send or receive signals from an appreciable portion of the galaxy, and since no great advance in technology is needed to build antenna systems that would measurably increase the chances of detecting signals from another planet, why not start listening and sending at once?

There are a number of factors that complicate the answer to that apparently simple question. One of the most important of them is the choice of a frequency at which to listen or transmit. (As we said earlier, electromagnetic radiation can be described either in terms of its frequency or of its wavelength, which are essentially two ways of describing the same thing; high frequency means low wavelength and vice versa.) The universe is awash with electromagnetic radiation of all frequencies. Planets emit infra-red radiation, stars twinkle in visible light, galaxies emit radio waves, other stellar bodies emit X rays and gamma waves,

and interstellar molecules emit their own distinctive radiation. If you were an advanced technical civilisation whose capabilities can only be guessed at by earthlings, what frequency would you use for your own interstellar beacons and for signals aimed at other civilisations?

The first major attempt to grapple with the question was made by Philip Morrison and Giuseppe Cocconi, who were then physicists at Cornell University, in one of the most important papers in the history of SETI. The paper was published in the prestigious British science journal *Nature* in September 1959, and it played a major role not only in getting SETI started but also in shaping all future discussion of the listening strategy that earth should follow.

To enter this discussion, we need a little vocabulary and an analogy. The vocabulary is that which scientists use to describe radio waves. If we describe the wavelength, the description is in terms of length. Most scientists use what Americans call the metric system, whose unit of length is the metre. Radio waves are best described in centimetres. One centimetre is one-hundredth of a metre and is 0.4 inch long – that is, 2.5 centimetres are roughly equal to one inch. Alternately, electromagnetic radiation can be described by its frequency. The unit of frequency is the Hertz, abbreviated Hz, which refers to cycles per second. Radio waves are in the range of millions of cycles per second, abbreviated MHz (for megahertz).

When Morrison and Cocconi were struck by the idea that interstellar communication by radio waves might be possible – and it was a daring idea for that time – radio astronomers had just discovered the distinctive emission of hydrogen atoms in space. The discovery was just the beginning of the continuing study of interstellar molecules, and it was enormously exciting in the budding field of radio astronomy. The radiation emitted by hydrogen atoms consists of 21-centimetre waves whose frequency is 1420 MHz. Its existence seemed to be an answer to a question that Morrison and Cocconi had been discussing.

The Main Street of Space

The question is best posed in the form of an analogy. Say that you have agreed to meet a friend in a strange town, and he casually says that you can get together with him on 'the main street'. If the town is small enough, there is no problem. But what is the 'main street' in a city the size of New York, or Boston, or

Los Angeles? If you are in New York, should you go to Fifth Avenue or Broadway or Main Street? The question can be answered if the two friends know each other's interests. If they are bankers, Wall Street would seem the logical place to try. If the theatre is their main interest, Times Square is the location to explore. If fashion is of interest, try Fifth Avenue.

Morrison and Cocconi assumed that the main interest of any technical civilisation that attempts interstellar communication would be science. And therefore, they said in the *Nature* paper, 'Just in the most favoured radio region there lies a unique, objective standard of frequency, which must be known to every observer in the universe: the outstanding radio emission line at 1420 Mc/sec.' (In those days, frequency was expressed in megacycles, or Mc, per second.)

As Morrison and Cocconi noted in their reference to 'the most favoured radio region', the hydrogen line has one major advantage. It lies in a quiet part of the radio spectrum, as seen from the surface of earth. To ground-based observers, most of the radio spectrum is quite noisy, so much so that it is impossible to detect individual sources of specific frequencies in space. The noise is caused by molecules in the earth's atmosphere – molecules of water and carbon dioxide and ozone and all the other gases in the air. These molecules absorb specific frequencies of incoming radiation. The molecules then emit radiation of the same frequencies, in effect blocking the extraterrestrial signals. Over a large portion of the radio spectrum, a radio astronomer on earth receives nothing but emissions from the atmosphere, which are no good at all for anyone who wants to study emissions from space.

But there is a 'window': a region of relatively low atmospheric noise, that starts at about 1000 MHz and extends to about 10,000 MHz. This is the 'most favoured radio region' to which Morrison and Cocconi referred. The hydrogen emission line of 1420 MHz is in this window. So is the emission line of the hydroxyl ion, which is made of one hydrogen atom joined to one oxygen atom, joined to one oxygen atom, and which emits at 1662 MHz. Between these two emission lines is the quietest part of the radio spectrum as seen from the surface of the earth.

One other point: if a hydrogen atom is joined to a hydroxyl ion, the product is a water molecule: H_2O. And, so Bernard Oliver says, 'The Cyclops team feels that this band, lying between the resonances of the two dissociated products of water, is the

fore-ordained interstellar communication band. What more poetic place could there be for water-based life to seek its own kind than the age-old meeting place for all species: *the water hole?*'

The 'Water Hole' of Space

Oliver, who has a tendency to wax poetic, expanded on the thought in a 1977 report of a SETI committee headed by Morrison:

> It is easy to dismiss this as romantic, chauvinistic nonsense, but is it? We suggest that it is chauvinistic and romantic but that it may not be nonsense.
>
> It is certainly chauvinistic to water-based life, but how restrictive is such chauvinism? Water is certain to be outgassed from the crusts of all terrestrial planets that have appreciable vulcanism and, therefore, a primitive atmosphere capable of producing the chemical precursors to life. We can expect seas to be a common feature of habitable planets. Exobiologists are becoming increasingly disenchanted with ammonia and silicon chemistries as bases for life. Water-based life is certainly the most common form and well may be the only (naturally occurring) form.
>
> Romantic? Certainly. But is not romance itself a quality peculiar to intelligence? Should we not expect advanced beings elsewhere to show such perceptions? By the dead reckoning of physics we have narrowed all the decades of the electromagnetic spectrum down to a single octave where conditions are best for interstellar contact. There, right in the middle, stand two signposts that taken together symbolise the medium in which all life we know began. Is it sensible not to heed such signposts? To say, in effect: I do not trust your message, it is too good to be true.
>
> *In the absence of any more cogent reason to prefer another frequency band, we suggest that the water hole be considered the primary preferred frequency band for interstellar search.*

In fact, the water hole is today the most favoured region of the radio spectrum for SETI. All plans for detecting signals from another civilisation centre on radio waves, and almost all of those plans are limited to the water hole. However, some thought has been given to other possible forms of interstellar communication.

One conceivable way of sending messages over interstellar distances is the laser, which emits an intense beam of light of very narrow wavelength. As early as 1961, Charles Townes, who was awarded the Nobel Prize in physics for developing a forerunner of the laser called the maser (the 'm' in maser stands for 'microwave') suggested that the earth could wink at other civilisations across interstellar distances by reflecting the beam of an extremely powerful laser off a very large mirror. The laser could transmit a message by blinking off and on, in a sort of interstellar semaphore.

It would seem at first that the light from any laser would be weak compared to that of the sun, but this problem can be overcome rather easily. There are a number of dark lines in the sun's emission spectrum, lines which mark the presence of elements that absorb light of specific wavelengths. Lasers that emitted light at one or more of these wavelengths could be used for the interstellar semaphore. Astronomers on another planet could detect the signal by noting first that the spectrum of the sun did not have a dark line at a frequency where one is expected; that, in fact, the sun was emitting an unusually large amount of energy in that frequency; and finally that the emissions were pulsed in such a way as to carry a message. It is true that the laser signal would be weakened by atmospheric absorption but that problem could be eliminated by putting the laser system into orbit around earth.

At the meeting in Armenia, Townes argued for a bigger SETI emphasis on lasers, which he said are especially suitable for communication with relatively close stellar neighbours, within ten light-years or so. 'Within five years our own possibilities will change and any civilisation that may be one hundred years beyond us may see things quite differently,' he said. A civilisation that had unlimited cheap energy and that lived on a planet with unusually intense winds might well prefer to use laser interstellar beacons, which require more power but smaller (and therefore less vulnerable) antennas than radio transmitters, Townes said.

In theory, lasers are a viable tool for SETI. At the moment, however, no one is talking with great enthusiasm about interstellar laser beacons. Money is one reason. Any interstellar communication system using lasers would be extremely expensive and would have no other use. The money to build such a system simply is not available. In addition, SETI is now concentrating on detecting signals from another civilisation, not on sending interstellar signals. Radio waves can be detected with existing

radio telescopes, which can be used for astronomical observations when they are not needed for SETI. To detect light signals from another civilisation, optical telescopes must be used. There is no surplus of optical telescopes, and viewing time on them is a scarce commodity. There have been no recent suggestions for a galactic search to detect intelligent signals in the optical region of the electromagnetic spectrum.

Some scientists in the SETI community entertain the thought that the water hole, which is an obvious galactic meeting place for a society in our stage of technical development, may be too primitive for a more advanced society. As Carl Sagan said in Armenia:

> Such societies will have discovered laws of nature and invented technologies whose applications will appear to us indistinguishable from magic. There is a serious question about whether such societies are concerned with communicating with us, any more than we are concerned with communicating with our protozoan or bacterial forebears. We may study micro-organisms, but we do not communicate with them . . . We may be like the inhabitants of the valleys of New Guinea who may communicate by runner or drum, but who are ignorant of the vast international radio and cable traffic passing over, around and through them.

Signals to Expect

There are a few theories around about the sort of signals we might expect from very advanced societies. Nikolai S. Kardashev, a Soviet radio astronomer, has classified civilisations by their technological stage of development. In Kardashev's grouping, a civilisation with the power output now possible on earth would be in Type I. A Type II civilisation would be able to harness the total energy output of a star like the sun; at the earth's present rate of energy growth, our civilisation would become Type II in about 3000 years. Finally, there is a Type III Kardashev civilisation, capable of using energy equivalent to the output of an entire galaxy.

In the United States, Freeman Dyson has proposed a comparable vision of an advanced technological society. A 'Dyson civilisation' would have the ability to literally take apart a planet and re-assemble its mass in a shell around a star, thus trapping all or most of the star's radiation. Originally, Dyson thought in terms of reshaping the planet into a solid shell around the star.

The mass of a planet the size of Jupiter would form a shell a few yards thick with a radius of a little more than 90 million miles, about the distance of the earth from the sun. People could live comfortably inside such a shell, which would give mankind the use of all the sun's energy, rather than the almost negligible fraction that now supports life on earth.

However, later calculations indicated that a Dyson sphere would be gravitationally unstable, so now a Dyson civilisation is envisioned as using a swarm of planetoids to trap the energy of its star. Such a scheme would still give a civilisation the use of an incredible amount of energy by current earthbound standards.

Both the Kardashev and Dyson proposals lend themselves to observational testing. A Dyson civilisation would change the radiation output of a star quite drastically, as seen from a distance. Instead of radiating primarily in the visual and radio regions of the spectrum, a star surrounded by a Dyson sphere would emit primarily infra-red radiation; the planetoids would absorb the higher-frequency radiation and would re-emit it in the form of infra-red radiation, or heat. A Kardashev Type III civilisation would have enough energy at its disposal to establish interstellar beacons whose distinctive signals could be detected through a large part of the universe. Kardashev went on to say that some known radio wave sources in the universe could possibly be such universal beacons. He named two in particular, cosmic radio sources named CTA-102 and CTA-21, whose signals have been seen to vary rhythmically. The variations could be carrying a coherent message, Kardashev said.

Astronomers have studied both CTA-21 and CTA-102 to determine whether their signals do carry a message. Several stars and galaxies that emit radiation primarily in the infra-red have also been studied to test the Dyson hypothesis. In both cases, the conclusion has been the same: if these objects are the work of intelligent beings, current science cannot say so. The peculiarities in the radiation emissions look natural, not artificial. If a Kardashev Type III civilisation or a Dyson civilisation does exist and if it is trying to communicate across space, its signals are too sophisticated for earth to detect now.

A few wilder speculations float around in SETI. Some scientists toy with the idea that an advanced civilisation communicates by using tachyons, which are hypothetical particles that can travel *only* faster than light. However, such speculations do not get SETI very far on the practical level. The tachyon hypothesis is fascinating on the theoretical level – for example, a tachyon

message would arrive at its destination before it left its point of origin – but no one has any idea of whether tachyons actually exist or how to harness them if they do exist.

Imaginative thinkers in the SETI community are constantly on the alert for some new development in physics that could provide an advanced alternative to communicating with radio waves. Nothing done on the frontiers of physics in the past couple of decades has produced such an alternative. In fact, the most detailed studies done recently have hardened support not only for communication by radio waves but also for using the water hole for interstellar signalling.

SETI: From Enfant Terrible *to Middle Age*

There are some practical reasons why the options for interstellar communication appear to have narrowed. The SETI community is still rather small, and a tendency for inbreeding has become apparent. The same names appear over and over on committees and panels. From a start as a scientific *enfant terrible*, SETI is beginning to settle into a comfortable middle age. In addition, radio-wave communication has the great advantage of being cheap and of being possible with existing equipment, extremely important factors as SETI begins to seek government funding. But there are also good scientific reasons: no really practical alternative to radio waves has developed, and the water hole in the radio spectrum seems more likely because of the biological work which indicates that life elsewhere in the universe probably is based on water, as it is one earth.

But even if we agree not only on radio waves but also on the water hole, the next question is: what strategy do we follow? Interestingly, the answer that is most accepted today is essentially the same one given in the very first days when interstellar signalling began to seem feasible.

Even before the Morrison-Cocconi paper was published in *Nature*, Cocconi wrote a letter to Sir Bernard Lovell, director of the Jodrell Bank radio telescope in England, at that time the largest radio antenna in existence, suggesting a search for 'beams of electromagnetic radiation modulated in a rational way, e.g. in trains corresponding to the prime numbers'. The tone of Cocconi's letter was half-apologetic for proposing a project that 'at first sight . . . looks like science fiction', and Lovell replied, briefly, that the observatory was too busy with other things to undertake such a search.

But the same idea that had occurred to Morrison and Cocconi had also struck Frank D. Drake, a young radio astronomer who was then at the new National Radio Astronomy Observatory at Green Bank, West Virginia. Even before Cocconi wrote to Lovell, Drake had conceived what he called Project Ozma, named after a princess in the L. Frank Baum stories of the imaginary Land of Oz, to search for intelligent signals from space. Drake was fortunate enough to have the support of the observatory's director, Otto Struve, who made time available for Project Ozma despite strong criticism and even ridicule from a large number of astronomers.

Drake chose two nearby sunlike stars, Tau Ceti and Epsilon Eridani, for Project Ozma. The programme began in April 1960. Listening was done in the neighbourhood of the hydrogen line, the 21-centimetre or 1420 MHz region. Drake's team periodically tuned the equipment to monitor about 4000 specific frequencies, each for a minute or so, from each of the two stars. Project Ozma went on for two months, a total of about 150 hours of actual listening, before the Green Bank radio telescope went back to its normal observations.

Project Ozma is important not only as a historic first, but also because it is the prototype for almost every listening project in SETI, actual or proposed, ever since. While one or two searches for extraterrestrial signals have taken a slightly different approach, most listening programmes have differed from Project Ozma only in detail. The changes that have occurred in listening programmes have been due primarily to advances in technology. Considering that both astronomy and electronics have made major advances since Project Ozma, the continuing reliance on its basic plan is a tribute to Drake's judgement.

Even though the importance of the hydroxyl emission line in space had not been discovered at the time of Project Ozma, its search was carried out in what would later become known as the water hole. In the two months of listening, a large number of what were then regarded as relatively narrow bandwidths, each about 100 cycles wide, were monitored, each for a brief period. Narrow bandwidth monitoring is a basic principle of most listening programmes, on the theory that any signal from an advanced technological society will be narrowly focused. By contrast, natural radio sources have wide bandwidths; they usually are

smeared out over many thousands of cycles. But as everyone who has ever tuned in a radio programme knows, artificial signals are concentrated in a narrow bandwidth. Even a slight turn of the radio dial is enough to lose a station.

One of the important changes in listening programmes since Project Ozma is the tendency to listen to narrower and narrower bandwidths. A number of theorists believe that a signal from another civilisation will be detected only by listening to a large number of extremely narrow bandwidths. These theorists believe that an extraterrestrial civilisation's signals are likely to be only a fraction of one cycle wide. Listening to narrow bandwidths makes the job much more difficult and time consuming, since the number of frequencies that must be scanned is greatly increased. It is only by using the latest electronic processing equipment that such a listening programme can be possible in a reasonable length of time. The cost of the processing equipment is not impossibly high, thanks to the great progress made in miniaturising electronic circuits, but the processor does have to be built specially. In addition, the processor must be used specifically for a listening programme, with not much spillover into general astronomical observations. Those last two points have become important in a growing controversy that threatens to divide the SETI community, as we will see in a few pages.

First, two other characteristics of Ozma should be mentioned, since both of them have become SETI commonplaces. The results of the listening programmes were negative, but there was a moment when it appeared possible that an extraterrestrial signal was being received.

Ozma's negative results were expected. Even in 1960, the available calculations about the possible number of extraterrestrial civilisations indicated that a relatively brief look at only two nearby stars was not likely to put earth in contact with another intelligent species. To this day, SETI is unusual among scientific disciplines because its practitioners begin their experiments with the expectation that they will not be successful, at least over the short run (and 'short' means years). The SETI community thinks in terms of decades or, in pessimistic moments, centuries, as the time required to make contact with an extraterrestrial civilisation.

SETI is such a young discipline that, by the law of averages, its results are bound to be negative. If there are one million advanced civilisations in our galaxy, arithmetic shows that only one star in 100,000 has such a civilisation. The probability of

detecting a signal from one of those civilisations in the first scan of two, or a dozen, or a hundred or even a thousand stars is extremely small. Yet if earth is to detect a signal from another civilisation, we must start somewhere. Project Ozma was that start. The fact that it found nothing was less important, in the minds of the SETI community, than the fact that the attempt was made at all.

The false alarm, an apparently coherent signal from outer space that later is found to have a terrestrial explanation, is a less well publicised feature of SETI projects that occurred first in Ozma. Not long after the antenna was pointed at Epsilon Eridani, a strong train of regularly pulsed radio signals was detected for a few minutes. No announcement of the detection was made. Several weeks later, Drake's researchers were able to determine that the signals came from a military facility that was doing radar research.

False Alarms

Even in the small number of limited SETI projects that have been undertaken since Ozma, false alarms keep occurring. Searchers in the United States and Canada have been extremely cautious about announcing the reception of signals from outer space – a caution whose wisdom has been borne out by experience. The Soviet SETI community has been more willing to rush into print and has been burned several times when announcements about 'extraterrestrial signals' have had to be withdrawn.

The most fascinating false alarm of all did not occur in any organised search for intelligent signals but as part of an ordinary exercise in radio astronomy. In 1967 a graduate student named Jocelyn Bell who was part of a group of radio astronomers at Cambridge University in England was doing a tedious analysis of signals that had been received by a new radio telescope when she noticed something odd. A regular, brief blip was showing up on the record – a series of unusually regular pulses at an interval of just over one second. The almost incredible regularity of the signals – they are precise to one part in 100 million – and the fact that analysis showed they had to be coming from a very small source seemed to argue against a natural origin. In the first euphoric hours after the discovery, the Cambridge astronomers named the source LGM-1. The initials stood for 'little green men'.

The Cambridge radio astronomers did not think that they had

received a coherent message from outer space. But the signals did appear to have the characteristics of an interstellar beacon system that a galactic civilisation might create to guide its starships. However, the thought that the signals might come from the galactic equivalent of lighthouses faded as other radio observatories swung into action. The LGM designation was dropped quickly. The sources of these precise pulses of radio signals today are called pulsars, and dozens are known to exist. A pulsar is believed to be a neutron star, one of the last stages in the life cycle of stars several times more massive than the sun. When such a star has exhausted its fusion fuel, it flares up briefly in a supernova explosion and then contracts until it has the density of an atomic nucleus. At this density, a star with several times the mass of the sun would be about as large as Manhattan Island. Spinning swiftly, the neutron stars hurls bursts of radiation into space at each revolution. When a burst reaches us, we can detect a pulse of radio waves.

The discovery of pulsars fulfilled a prediction that had been made by astrophysicists about the last stages of the life cycle of stars. But interstellar beacons, no.

The most widely publicised Soviet false alarm occurred in 1973. In October of that year, the Soviet press agency Tass carried a report saying that Soviet radio astronomers had detected radio signals that occurred at regular intervals and did not seem to be of terrestrial origin. Later, one of the astronomers, Nikolai Kardashev, was quoted as saying that the signals 'might have come from an artifact which had entered the solar system' – that is, an interstellar probe.

Until now, the Soviet approach to SETI has been somewhat different from that adopted in the United States. US searchers like to use highly sophisticated equipment in an effort to detect subtle signals from individual star systems. The Soviets have tended to use comparatively simple antennas in an effort to detect powerful unmistakable signals from a highly advanced society, such as a Kardashev Type III civilisation.

Starting in 1968 Vsevolod Troitsky and other radio astronomers did make an Ozma-type search of about a dozen nearby sunlike stars using a radio telescope at Gorky State University. They heard no artificial signals at the two frequencies they tried, the 21-centimetre line and the 30-centimetre line. Later, Troitsky's group set up a network of six widely spaced stations – in Siberia, the Crimea, at Gorky, and at Murmansk, and two locations – to detect pusled signals from the sky at wavelengths of 16, 30, and

50 centimetres. Kardashev and a colleague, Lev Gindilis, established a comparable network using stations in the northern Caucasus and in the Pamir Mountains, about 1800 miles apart.

Both networks did detect a number of regular pulses that stood out from the background noise. The origin of most of those pulses was tracked down. Some came from an artificial satellite; others from natural emissions from the sun or the ionosphere. The signals that led to the Tass report in 1973 appeared to have no such explanation. They did seem to be coming from a satellite, but not from any known satellite of terrestrial origin. Hence Kardashev's reported belief that a space probe of the sort described by Bracewell had been detected.

Western scientists were sceptical from the start, and their scepticism has been borne out. The latest word from the Soviet Union is that the signals were traced back to a military satellite launched by the United States. An earlier Soviet report in April 1965, in which Tass said, 'Scientists at the Shternberg Astronomical Institute believe they have received perhaps the first evidence that we are not alone in the universe,' was also a false alarm. The periodically varying radio signals detected by astronomer Gennardy Sholomitsky were found to come from a quasar, a natural (if still somewhat mysterious) body in space. It was a Soviet counterpart of the LGM episode.

One measure of the hold that SETI has on the minds of many people is the failure of false alarms and negative results to discourage interest in the search. At the annual meeting of the American Association for the Advancement of Science in Boston in 1974, one of the biggest conference rooms was filled to capacity for a session on SETI, even though the subject matter was nothing more than unsuccessful searches. The session was a milestone because its arrangers were able to report on an unprecedented total of six searches for extraterrestrial civilisations. Most of them are still going on.

Outside the Soviet Union, the first search after Ozma was made at Green Bank by astronomer Gerritt Verschuur. In 1971 and 1972, Verschuur looked at the hydrogen line of ten nearby stars, including Tau Ceti and Epsilon Eridani. As expected, he heard nothing unusual.

In 1972 Patrick Palmer of the University of Chicago and Ben M. Zuckerman of the University of Maryland began what they called Project Ozma II. The differences between the two Ozma

projects show how fast SETI had moved in a dozen years. Instead of just two stars, Palmer and Zuckerman studied hundreds, and their equipment took just a fraction of a second to accomplish what had required 150 hours of listening in 1960.

Project Ozma II used the 300-foot antenna at Green Bank and listened on 384 separate bandwidths centred on the hydrogen line (21 centimetres or 1420 MHz). The stars that were selected for the survey were 'very nearby on an astronomcal scale; that is, within about sixty light-years of the earth'. Palmer and Zuckerman studied only sunlike stars that were prime candidates for life; stars that are too old or too young, those that are too big or too small were eliminated. Even with these restrictions, they had a list of more than 500 stars to scan.

They made their observations in week-long blocks of time between November 1972 and August 1975. During each week, about 150 stars were monitored for about four minutes a day. After using the 300-foot antenna to study the original list of stars, the 140-foot antenna at Green Bank was aimed at about 130 more, bringing the total to 659 stars. In addition, the 140-foot antenna was used for a further scan of ten stars whose original data contained something unusual. In all, Palmer and Zuckerman accumulated nearly 20 million data points in some 51,700 individual star spectra. They first ran the data through the computer and then checked it all again by hand. Most of the 'glitches' in the data were explainable. The few that couldn't be traced back to terrestrial sources were one-time phenomena, rather than the repeated trains of pulses to be expected in an interstellar beacon. Results: negative.

Up in Canada, Alan H. Bridle of Queens University in Kingston, Ontario, and Paul A. Feldman of the National Research Council began looking at the water emission line (2220 MHz), using the 150-foot radio telescope at the Algonquin Park Radio Observatory, in 1974. At the 1976 meeting, they reported that they had scanned 28 stars, and, despite frequent equipment trouble, hoped to examine a total of 500 stars. There were, of course, no intelligent interstellar signals, but astronomers at Algonquin Park were able to detect the heaviest interstellar molecule found until then, a compound called cyanodiacetylene. By early 1978, Bridle and Feldman had looked at 150 stars, still with negative results.

Galactic Sweeps

Other searchers are a bit more off the beaten path. Carl Sagan and Frank Drake have used the 1000-foot radio telescope at Arecibo to study whole galaxies. The advantage of such a search is that it is a nice, wholesale approach to SETI. Instead of surveying one star at a time, a galactic search takes in anywhere from 100 billion to 250 billion stars in a swoop. The disadvantage is that only a highly advanced civilisation that is beaming extremely strong signals can be detected. Drake estimates that the Arecibo telescope, the largest on earth, could pick up signals in a galactic search only if they were sent with a million times the maximum power of the Arecibo antenna. The Arecibo galactic sweep uses four different frequencies – the hydrogen line, the hydroxyl line, a line at 1652 MHz in the middle of the water hole, and 2380 MHz, which happens to be the frequency that the Arecibo telescope utilises when it is used as a radar facility. The first galaxies monitored were Leo 1, Leo 2, Messier 33, and Messier 49. There was the usual false alarm, a moment when a peak appeared in the 1420-MHz signal from Leo 1, but the same peak appeared when the antenna was not pointed at the galaxy. The signal probably came from a gas cloud in interstellar space.

Sagan and Drake hope to do more galactic sweeps (Bridle and Feldman have a list of 150 galaxies they would like to study with the Arecibo radio telescope), but their project is handicapped because the search for extraterrestrial signals must be fitted into unused moments in the telescope's schedule. Those moments are rare since radio astronomers queue up for months to get observing time at Arecibo.

At Ohio State University, radio astronomer Robert S. Dixon and some colleagues are trying a low-cost approach to SETI. They have rigged up the equivalent of a 175-foot antenna using equipment scrounged from various sources, and they run their search almost around the clock, leaving the machine unattended. The Ohio State device is methodically surveying as much of the sky as is possible at the 21-centimetre line. Dixon and his group started the scan in December 1973; as of 1977, they had detected no unexplainable signals in the segment of the sky they had looked at (between +48° and +14° declination, for the record). The few blips that did show up were traced back to terrestrial radar facilities. However, the Ohio State group did pick up signals from a number of natural radio sources that appeared worthy of

further astrophysical study.

A couple of points about these searches: negative results for SETI are not necessarily completely negative for astronomy. Useful astronomical data is being collected even in the first rather limited and inexpensive efforts. As the SETI community begins to press its case for a bigger, better-funded programme, it is starting to stress the benefits to astronomy of its scans.

And there's a lot more going on in SETI than most people realise. Add up all the observations that have been made, and it seems that many hundreds of stars and a fair fraction of the sky have been surveyed in one way or another for intelligent signals. After hearing the reports at the American Association for the Advancement of Science meeting, Philip Morrison suggested that the time had come for SETI to get organised, so that duplication of effort would be avoided. There are two sides to that question. It is certainly true that, even at this early stage of the search for extraterrestrial signals, searchers tend to repeat what others have already done. For example, almost everyone who has started a search programme seems to have looked at Tai Ceti and Epsilon Eridani, Drake's two original targets for Ozma. Barnard's star is another favourite. And, in addition to looking at the same stars, searchers stick to the same frequencies, usually the 21-centimetre line.

On the other hand, repeated searches of the same stars in the same frequencies are not necessarily wasteful. We cannot assume that an advanced civilisation will beam an interstellar beacon constantly towards the earth; in fact, it is safer to assume that such a beacon would be directed towards earth only intermittently. Therefore it seems prudent to keep checking likely stars periodically. Since the number of stars that has been scanned so far is not much more than 1000, SETI cannot be said to have reached a point where duplication of effort is a real problem.

But that point may be reached as more searches are begun. As of 1978, there were eight continuing programmes – one in the Soviet Union, the Bridle-Feldman programme in Canada, and six in the United States. The last entry on the United States list is an indication of how searches might multiply because of the effects of the cost revolutions in electronics.

The cost of carrying out a search for extraterrestrial signals is going down because the cost of the electronic equipment needed for the search is dropping extremely rapidly. A single chip that now costs less than $20 contains the circuitry that went into the heart of a million-dollar computer of the 1950s. A searcher can

now use such low-cost equipment for a low-cost listening programme that involves very little effort.

Late in 1977, a group of graduate students working under the direction of Stuart Bower, a professor of astronomy at the University of California at Berkeley, set up such a programme. They call it SERENDIP, which is an acronym for Search for Extraterrestrial Radio Emission from Nearby Developed Intelligent Populations. The acronym is a reference to serendipity, the knack of finding useful things even though one is not looking for them.

For about $4000, the students built a system that is attached to the 85-foot radio telescope at the university's Hat Creek Observatory, near Mount Lassen in northern California. The system consists of a noise analyser, a computer, and a tape recorder. As the antenna goes about its ordinary business, the analyser and the computer search 100 different frequencies for unusual signals. Anything out of the ordinary trips the tape recorder into action, recording not only the location of the signal but also the time when it was received. The tape is reviewed once a month at Berkeley to determine whether any of the unusual signals appears to be an intelligent transmission.

Other listening programmes are also being done on a sporadic basis, when time can be spared at major installations. For instance, Frank Drake and Mark A. Stull of the Ames Research Center used the Arecibo antenna in 1977 for a study of six stars. They looked at frequencies in the 1664–1668 MHz, near the hydroxyl line. Also in 1977, five days of observing time on the 300-foot antenna at Green Bank were allotted to four astronomers: Jeffrey N. Cuzzi, Thomas A. Clark, Jill C. Tarter and David C. Black. They looked at 200 sunlike stars within the 1665–1667 MHz range, again near the hydroxyl line.

Both searches were negative, of course. They do, however, add to the growing volume of what can be called background information in SETI: information that is comparable to the many thousands of photographic plates that astronomers have accumulated over decades of viewing and photographing the stars. When anything new is found in the heavens, astronomers can go back through the old plates to see whether there were previous sightings of the phenomenon. In the same way, astronomers who are searching for unusual signals from advanced civilisations may someday be faced with the problem of analysing a borderline signal from a star. If the information that is being gathered by a

growing number of individuals is properly filed and indexed, it can help greatly in determining whether the signal does indeed contain a message.

Of course, the search for a message in a signal is helped greatly if the searcher has an idea of what form a message might take. Scientists in the SETI community have been thinking about that problem for a long time. It might not seem easy to visualise a message from beings whose nature is unknown and whose home planet is completely foreign to us. But a start has been made at a theory of interstellar signalling.

CHAPTER TEN

Messages

Listening programmes assume that someone is sending a message. But what sort of message? The initial answer to that question is: something very like the signals that pulsars transmit. Martin Ryle, who was to share the Nobel Prize in physics for work that included the discovery of pulsars (Jocelyn Bell did not get a share of the prize, which many observers believe is unfair), later recalled that when the discovery was made, 'Our first thought was that this was another intelligent race trying to reach us.'

But that does not really answer the question. Assuming that an intelligent species is trying to reach out across almost incalculable distances to make contact with another species, what can it say? Remember: the two species have nothing in common but intelligence; their star systems, planets, genetics, environment all are likely to be quite different. Remember also that human beings, who share the same genetics, planet, brain, and body can have great difficulty in understanding each other over distances of only a few miles. The difficulties are compounded if human contact is made over greater distances. Much of the history of the nineteenth and twentieth centuries is the unhappy story of the collision of two human societies that share everything but a common background. If members of a species on a single planet can encounter such problems trying to communicate, what message can be sent from one intelligent species to another across the void of space?

At the beginning of the twentieth century, the idiosyncratic inventor Nikola Tesla, who thought he had detected signals from another planet, had the essential idea of what they should contain. He envisioned the time when mankind received 'a message from another world, unknown and remote. It reads: one . . . two . . . three . . .'

Tesla's idea contained the core of the concepts that most people in the SETI community still hold about interstellar messages. The SETI community, which consists almost entirely of scientists and engineers, assumes that a SETI community on another planet will have the same technical orientation. Scientists and engineers talk largely in mathematics when they are in formal communication with one another. Therefore it is assumed that scientists and engineers trying to talk across space will also use mathematics as their language. As Tesla understood, two intelligent groups that have no words in common cannot help but understand the basic principle of counting starting with a single unit and adding one at a time. The simplest way to make an intelligent species on another planet understand that a coherent message is being sent is to start with a single pulse, follow it with two, follow that with three, and continue up to, say, ten, and then start again.

But simplicity does not mean efficiency. Interstellar communication would take place across such vast distances that the transmitting society would want to reduce the time for a reply to a minimum. If the receiving society were only fifty light-years away – not a very great distance by galactic standards – the senders could not expect an answer in less than a century. If the first society says only the interstellar equivalent of 'hello', it will be 150 years before a real dialogue can begin: 50 for the message to be received, 50 for an answer to be transmitted, and another 50 for the first society to reply.

The round trip time can be cut considerably if the original message includes a large amount of basic information about the transmitting society: its location in the galaxy and in its planetary system, the genetics of the transmitting species, and other organisms on its planet, and so on. At the conference in Armenia, several of the participants toyed with the idea of transmitting a train of signals that could be put together at the receiving end as an actual picture of an earth creature such as a cat. But S. Y. Braude, one of the Soviet scientists at the meeting, pointed out, 'You are transmitting a picture, but that same picture will be

received in another world and interpreted in a certain way. Don't you think that it may happen that in another world with creatures with a different refractive index, the pictures will be distorted and the cat will be nothing like the cat because the medium is different?'

Sending Mathematical Pictures

The current reigning concept in the SETI community nevertheless does visualise a sort of picture being sent across the galaxy – but a picture that is based on mathematical concepts and one that cannot be distorted by the differences mentioned by Braude. We owe this concept primarily to Frank Drake. Just as Drake set the standard for most of today's listening programmes with Project Ozma, so he set the standard for most of today's concepts of interstellar messages.

The first scientific meeting on intelligent extraterrestrial life in the United States was held at Green Bank in 1961. Drake was one of the participants. At the end of the meeting, he sent each of the other participants a message consisting of 551 zeroes and ones, in what seemed to be random order. His challenge to them: decode this message.

To the participants in the conference, the first step in decoding was simple. There were 551 characters in the message, and 551 can be divided by only two numbers: 19 and 29. Therefore the characters had to be arranged either in 19 groups of 29 characters or 29 groups of 19 characters. The second step was also simple: a zero was taken as a white background square and a one was taken to be a black message unit square (reversing the colour scheme does not change the basic idea). When the squares were arranged in the proper array, figures and some regularly ordered sequences are apparent. The third step in the decoding process is to determine the meaning of the figures and the sequences. Some of the participants did, some didn't. Still later, Carl Sagan, Drake's partner, asked some scientists to decode a message that was similar to the one devised by Drake in every respect but one: a single zero was missing. No one could make sense of the resulting jumble.

Leaving out a single pulse eliminates one of the most important clues to interpreting the message: the fact that the number of characters in the message is divisible by only two numbers. But there are other pitfalls, as can be seen by an effort to decode a

very similar message, one which has a place (however small) in the history of communication with other planets. This latter message contains the same sort of information that was transmitted in Drake's original 551-character message. It is unusual because of the recipients for whom it was intended.

Drake's Message: 'An Anti-Puzzle'

Always willing to pioneer, Drake has the distinction of being the first person on earth to transmit a coded message towards the cosmos. The message was transmitted at 1.30 p.m. on Saturday, 16 November 1974. The occasion was the rededication of the Arecibo radio telescope, whose 1000-foot dish had been resurfaced to increase its sensitivity. To send the message, the radio telescope was used as a transmitter. In theory, it can communicate with an antenna of equal size anywhere in our galaxy. However, the message was sent towards another galaxy, a globular cluster known as M-13 which contains some 300,000 stars and is 25,000 light-years from earth. Three minutes were needed to transmit a total of 1679 pulses consisting of two alternating whines in the radio signal. Drake called the message 'an anti-puzzle', adding that it is 'a code designed to be easily broken'.

The message is shown in Figure 2, a pictogram which was produced by arranging the 1679 pulses in an array of 23 by 73 characters – they are the only two numbers by which 1679 is divisible – and colouring the 'on' pulses and the 'off' pulses white. It is an anti-puzzle that needs some explaining for those lacking the proper training.

The language of the message is that of binary arithmetic, in which there are only two numerals: 0 and 1. The top row of the message tells how to count from one to 10 in binary numbers. Just below the binary arithmetic lesson is a group that can be recognised as five numbers – from right to left, the numbers 1,6,7,8, and 15. These are the atomic numbers of hydrogen, carbon, nitrogen, oxygen, and phosphorus, all of which are essential to life on earth.

Assuming that an alien civilisation now understand both the language of the message and the essentials of chemistry, the anti-puzzle gets seriously into biochemistry. There are two rows which picture the components of nucleic acids – a phosphate group, a molecule of deoxyribose, and the formulas for thymine, adenine, guanine, and cytosine. Put them all together and they form DNA. An explanation issued by the Arecibo observatory before the

message was sent said that 'knowledgeable organic chemists anywhere should be able through rather simple logic to arrive at a unique solution for the molecular structures being described here'. This assumes, of course, that DNA is the molecule that contains the genetic information of the species that receives the message, just as it is the genetic molecule of life on earth. The curlicues in the centre of the message represent the helix in which the DNA molecule occurs, and the block of squares in the middle of the helix gives the binary number for four billion, the number of nucleotide pairs in human DNA.

Now the message abandons pure arithmentic to show a crude picture of a human being, which is flanked on the right by a line running from its head to its feet and the binary number 14. This says that the human is 14 units tall: the species decoding the message is expected to know that the unit is the wavelength of the transmission 12.6 centimetres, which would make the figure 5 feet 9½ inches tall. On the left of the figure is another binary designation of the number four billion, the number of people on earth at the time the message was sent.

Next comes a rough sketch of the solar system, with the sun to the right and the nine planets strung out towards the left. There is some attempt to indicate the relative sizes of the planets, and the figure for the third planet is displaced slightly towards the human figure to indicate that it is the home planet of the species that sent the message. At the bottom there is the image of a radio telescope, and an indication of its size – 2430 wavelengths across, or 1004 feet.

'This information tells indirectly, when taken with the strength of our signal, a great deal about the level of our technology,' the observatory's explanation said. 'If the message is transmitted repeatedly, a desired impression is made that the message emerges from the telescope.'

A great deal was made of the Arecibo message, both before and after it was sent. Drake and his colleagues tried out various forms of the message on a number of scientists to see how well they could decode it. Most of them understood the greater part of the message; whether an intelligent species in another galaxy would have any success at all cannot be said.

Those in favour of the message described it as historic. But there was grumbling because the international SETI community had not been consulted before a message was sent. After all, there had been an informal agreement at the meeting in Armenia that no one nation should start communicating with other civilisations

on its own. A Soviet report in 1976 expressed the hope 'that there will be further international discussions on the subject before such a programme of transmissions is launched'.

Actually, Drake indicated in an interview not long after the telescope re-dedication that the message was regarded more as a symbol than as a serious effort at interstellar communication. The frequency chosen for the signal was not any one of the recommended lines that have been discussed so frequently. While the observatory explanation spoke of a message being 'transmitted repeatedly', it was in fact sent only once. And it was sent not towards any nearby sunlike star but towards a galaxy at which the antenna happened to be aimed at the time of the re-dedication ceremonies. Since about 50,000 years would be needed for the message to be received, understood, and answered by an intelligent civilisation in M-13, the breach of earth's security by the Arecibo adventure is not calamitous. If the recipients come towards us with evil in mind, earth has a lot of time to prepare for them.

Message to Jupiter

We will have even more time to prepare for an earlier message that was launched towards the cosmos, the plaque that was placed on the Pioneer 10 and 11 spacecraft. Pioneer 10 was launched on 3 March 1972 for its mission to Jupiter. Before the launch, late in 1971, a science writer named Eric Burgess pointed out to Carl Sagan that Pioneer 10 would eventually leave the solar system, and so could carry a message from earth to outer space. Sagan got in touch with the appropriate authorities and was told, to his surprise, that no one objected to the idea of putting a message aboard the spacecraft. Within three weeks, the plan for what Sagan later called 'a message in a space-age bottle' was proposed, approved, and carried out.

The result was the plaque that is shown in Figure 3. Its message was the result of a quick conference between Sagan and Drake; the human figures were drawn by Sagan's wife, Linda Salzman Sagan. The figures were etched on six-by-nine-inch plaques that were attached to the antenna support struts of both Pioneer 10 and Pioneer 11, which was launched in 1973.

At the top of the plaque is a representation of two hydrogen atoms, drawn so as to indicate to a scientist that they are emitting 21-centimetre radiation. The binary number 1 is beneath the

atoms. At the left centre is a pattern of radiating lines, each line with a long binary number. As Sagan explains it, if the numbers are interpreted as meaning distance, the diagram makes no sense, since the distances (in terms of the binary number times the 21-centimetre marker) are too small by interstellar standards. But if the numbers are interpreted as time intervals, they are supposed to make sense to an astronomer: the lines represent pulsars, and the numbers represent the time between emissions of radio-wave bursts by each pulsar. The length of the line represents the distance from each pulsar to earth, which is at the point where all fourteen lines converge.

By using the pulsar segment of the diagram, an extraterrestrial astronomer will be able to locate the source of the message. In addition, the astronomer would also be able to determine when the message was launched. The period of each pulsar is indicated with great precision, as of the time of launch. But pulsars run down slowly, so that the interval between bursts grows longer as time goes on. By comparing the current interval with that indicated on the dial, an extraterrestrial astronomer could hit on 1972 as the year of the spacecraft's launch.

The rest of the message consists of pictures: at the bottom, a picture of the solar system, with binary numbers indicating the scale, and a schematic representation of the spacecraft leaving the earth. At the right are a nude couple, with an outline of the spacecraft behind them and binary numbers to the right indicating their size.

Naturally, the nudes got most of the attention. The *New York Daily News* headline on the story said: 'Nudes and Maps Tell About Earth to Other Worlds.' There were complaints from some people that (a) putting a nude on a spacecraft is obscene; (b) the woman is pictured as passive while the man is active, which is not equality; (c) the figures look too Caucasian; and (d) that no extraterrestrial species could make any sense out of the drawing. An unauthorised version of the plaque that circulated during the Pioneer 10 encounter with Jupiter showed the man raising more than his right hand in friendship.

Citizens wrote letters and newspapers wrote editorials about the significance of the plaque. The great room that exists for determining its significance is indicated by the fact that Sagan later referred to the Pioneer message as 'mankind's first serious attempt to communicate with extraterrestrial civilisations', 'a message to back here' and 'good fun'. The last idea deserves some

defence. If Pioneer 10 were travelling to the nearest star, it would arrive in 80,000 years. In fact, it is going nowhere in particular. By chance, it will travel towards a part of space where there are no important objects. Since the plaque is made of gold-anodised aluminium and the erosion rate in outer space is low, the plaque should last for many millions of years. Thus, if there are intelligent species out there and if they are roving the void of interstellar space, they might eventually find the plaque. The chances of that happening are infinitesimally small. Still, the thought of a virtually indestructible message from humanity sailing off into the cosmos intrigues many people.

The concept is so intriguing that the National Aeronautics and Space Administration did it again when two Voyager spacecraft were launched on a Jupiter-Saturn mission in 1977. This time the message was far more elaborate than the one carried by the Pioneer spacecraft, although whether it represents an improvement can be debated. This was a space message that was decided by committee.

Phonograph Records in Space

Instead of a plaque, the message is carried by a phonograph record, a twelve-inch copper disc made to be played at 16⅔ revolutions per minute. For the benefit of any extraterrestrials who come across the record, each of the Voyager spacecraft also carries ceramic phonograph cartridges and a needle; the whole package is in an aluminium container upon whose lid are pictures showing the speed at which the record should be played and the way that the cartridge should be used.

The record itself begins with a long train of signals that can be interpretated to form pictures. To start with, the picture sequence places the earth in space, first showing the solar system and then moving in on our home planet. After this lesson in astronomy comes a lesson in terrestrial biology. There are pictures of DNA and of living cells, and then the sequence moves on to human anatomy.

However, to the great amusement of NASA-watchers, the space agency drew the line at showing human reproduction. Originally, the sequence was to have included some clinical diagrams showing how babies are made and born. Remembering the reaction to the nudes on the Pioneer plaque, the committee that designed the Voyager message kept it as conservative as possible. The sequence of human reproduction included only a

man and a pregnant woman, with a diagram showing the location of the foetus. Even that was too much for the space agency.

Too smutty, said NASA, which eliminated the pregnancy sequence entirely from the plaque. A reporter who called Herbert Rowe, NASA's associate administrator for external affairs, was told that the pregnancy picture 'was not appropriate for inclusion'. NASA also drew the line at sketches showing human sex organs. Voyager went into space with a sexless human species aboard. It did, however, include the names of all the members of the House and Senate committees in charge of space science.

At any rate, any being who finds the record, plays it, and deciphers the pictures will get a full look at the earth and its inhabitants a diagram of the earth's internal structure and another of continental drift; pictures of the Snake River and the Grand Tetons in the American West; the majestic Monument Valley in which John Ford has filmed many of his classic Westerns; pictures of trees, insects, animals, and birds; Jane Goodall observing chimpanzees; a selection of the world's different peoples, from an old Turkish man to a Balinese dancer; the Great Wall of China and the Sydney Opera House; a sunset with birds and the Arecibo radio telescope. And more.

The record also contains greetings in a variety of human tongues, fifty-five in all, from Akkadian to Wu, a Shanghai dialect. Akkadian, which heads the alphabetic list, is also the oldest language on the record. It was spoken by the ancient Sumerians and is probably the oldest known language. Then come greetings from Kurt Waldheim, Secretary General of the United Nations, and from President Jimmy Carter. After that is a sequence of the 'sounds of earth', staring with the 'greeting call' of a whale and including the eruption of a volcano, the sounds of rain and surf, and a train whistle, and ending with a kiss, the sound of medical instruments, and recorded pulsar sounds.

The record ends with music. In his book, *The Lives of a Cell*, Dr Lewis Thomas says that if he were to choose a message to space, 'I would vote for Bach, all of Bach, streamed out into space over and over again.' In fact, the record does begin with Bach – the first movement of the Second Brandenburg Concerto. It is followed by Javanese gamelan music, percussion music from Senegal, a Mexican mariachi band, and so on to the concluding selection, the great Cavatina from Beethoven's Thirteenth String Quartet.

You could say, as Carl Sagan did, that 'the launching of this bottle into the cosmic ocean says something very hopeful about life on this planet'. Or you could say that the message doesn't mean very much in practical terms. Voyager 1 will not leave the solar system until 1987, when it passes the orbit of Pluto. Voyager 2 will be about two years behind. In about 40,000 years, both spacecraft will pass within one to two light-years of a minor star. There will be other near approaches to stars, 147,000 and 525,000 years after launch. If technical societies survive on earth and continue to grow in the way that they have in the past, it is probable that high-velocity space probes, perhaps with human crews aboard, will be roaming through the galaxy by that time, or that a full-time interstellar beacon will be transmitted from powerful terrestrial antennas. If today's technological society comes to a sticky end, sending a mesage by spacecraft will not accomplish anything. Either way, logic says that we should wait for a while.

However, logic doesn't seem to have much to do with it. The meaning of these messages is symbolic. They keep the SETI spirit alive until some more meaningful steps can be taken.

In reality, the clearest messages that earth has sent into space have been unwitting. We have sent a variety of them, all easily decodable by any intelligent species that happens to intercept them. They are the normal radio, television, and radar signals emitted by transmitters who have no idea at all of signalling to another civilisation.

Very faint traces of the first radio transmission made on earth now are about 80 light-years from us. These are not very important as interstellar signals because most radio waves bounce back from the ionosphere, so that the radio signals sent into space are barely detectable. But signals in the microwave region go out into space almost unhindered. Television and radar use frequencies in this region of the spectrum; tall antennas are needed for television stations because the signal is not reflected back to earth as the transmissions of radio stations are. Several people in SETI have pointed out that the earth is now surrounded by a growing bubble of electromagnetic radiation that carries the full selection of early television broadcasts. In addition, there are radar signals, the most powerful of which come from the huge systems built for military purposes. These are our first messengers to space.

In 1978 astronomer W. T. Sullivan of the University of Washington, assisted by two undergraduates, made what appeared to be the first detailed study of such signals from earth. Sullivan concluded that the most powerful signals which we are emitting come from BMEWS – ballistic missile early warning system – radar sets, which can be detected at a distance of 250 light-years by a society with our present technology. However, Sullivan said that BMEWS transmissions are not likely to give much information to a distant observer, for two reasons: there are only a few BMEWS transmitters, and their frequencies are shifted constantly for security reasons. At best, Sullivan said, BMEWS radar systems 'may well act as "acquisition signals" to the outside observer, announcing our presence, but yielding only a minimum amount of further information'.

Television stations are a much better source of information about the earth, Sullivan said. There are about 15,000 television transmitters on earth, more than 2100 of them with effective power of 50 kilowatts or more. Nearly half the transmitters are in North America, about 30 per cent are in Western Europe, 6 per cent are in Eastern Europe, and the rest are elsewhere. An observer who kept careful watch on the way in which the signals from these stations appeared and vanished with the turning of the earth could get a great deal of information, Sullivan said:

> After several years of careful monitoring of the intensity and frequency variation of several hundred stations, the observer could deduce (i) the complete orbit of the earth; (ii) the existence of station broadcast schedules influenced by the sun; (iii) the presence of an ionosphere and perhaps even a troposphere; (iv) the size, rotation rate and axis of rotation of the earth; (v) a complete map of the stations; (vi) the mass and distance to the moon; (vii) and the size of the radiating antennas; and (viii) various cultural inferences concerning our civilisation.

However, this wealth of information is not widely available to listeners in the galaxy. Sullivan calculated that the earth's television signals can be detected by listeners at our level of technology only within a radius of 25 light-years. There are about 300 stars in that volume of space – a large number in the abstract, but a small number by standards of the SETI formula.

These signals are not negligible. In some radio frequencies, the earth radiates more energy than the sun. However, the consensus

in SETI right now is that these signals are not likely to be detected by another civilisation. Even if another civilisation is looking for signals, 'leaked' radiation transmissions, such as those from TV and radar, are not very easy to detect. The carrier frequency of a television station is only one-tenth of a hertz wide, and it carries no information. To detect the programme content of a television signal, a listener needs an antenna that is 1000 times more sensitive than the one needed to pick up the carrier frequency. In addition, the 25-light-year radius in which these signals are detectable represents a negligible distance in a discipline that deals in hundreds or thousands of light-years. Finally, the earth's transmissions of such signals may lessen in the years ahead because more signals are being sent by cable, as in home cable television. A television signal sent over a coaxial cable does not go into space, and an increasing percentage of our signals are transmitted by cable. Today's microwave towers, which spill radiation into space, may also be replaced by cables made of clear glass, which transmit light waves and do not radiate into space. Telephone companies are experimenting with laser-wave transmissions because the shorter wavelengths of visible light can carry much more information than microwaves. The use of lasers will also reduce unintentional transmissions into space.

Right now, a properly turned viewer on a nearby planet would see the earth glowing brightly in a few radio frequencies. In several decades, the glow might wink out as corporations and governments move to more efficient modes of transmission. If it happens on earth, we can assume that the same thing has happened on more advanced planets. Therefore we cannot count on making accidental contact with another civilisation that has picked up or leaked radiation. We cannot even assume that another civilisation is searching for such leaked radiation because that civilisation's scientists probably will have concluded that the search would not be successful. If another civilisation has its antennas pointed towards earth, it is almost certainly trying to detect an interstellar beacon.

Catch 22: Earth cannot send such a beacon at this stage of our history, largely for practical reasons. The Arecibo radio telescope could theoretically send a signal to an antenna of similar size anywhere in the galaxy, but no radio astronomer wants the earth's largest telescope dedicated to endless transmissions to an unknown receiver. Even a smaller antenna, such as the 300-foot

dish at Green Bank, is too valuable to use for sending interstellar signals.

In theory, we could build a 300-foot antenna and use it solely for sending signals to other stars where there might be intelligent civilisations. The study made for Project Cyclops calculated that a 300-foot antenna would be capable of picking up a signal from another 300-foot antenna 80 light-years away. In theory, the matter would be simple: just pick out all the sunlike stars within 80 light-years, encode the message, and beam the message at each of the stars for a few days at a time. The antenna could either have a twin that would survey the same stars for return transmissions, or it could spend half its time listening and half its time sending.

That's theory. In practice, sending an interstellar signal is not in fashion in SETI right now. One reason is the international complications that might ensue if only one nation began transmitting. A recent Soviet statement said, 'Soviet scientists have no plans at present to send out signals addressed to extraterrestrial civilisations. They share Sir Martin Ryle's hope that there will be further international discussions on the subject before such a programme of transmissions is launched.'

The Fear of Contact

Sir Martin Ryle won the Nobel Prize in physics in 1974 for his role in the discovery of pulsars and for other contributions to astronomy. In 1976 he wrote both to Frank Drake and to the International Astronomical Union proposing an international agreement not to send interstellar messages from earth. His motive was fear – fear that an advanced society would follow the beacon to earth with plunder in mind. Perhaps the civilisation that received the signal would want to colonise the earth, or perhaps it would want earth's mineral resources, Ryle believes.

Most members of the SETI community do not share that concern. It is generally believed that any civilisation which can travel across the vast distances of space will have no need for any of earth's resources, including its inhabitants. As the recent history of our planet shows, slavery makes economic sense only for societies in a low state of technological development. As for resources, the earth has nothing that an advanced civilisation needs. Already there is talk on earth of mining the minerals of the asteroids, the flock of planetoids that swarm between Mars and Jupiter. Freeman Dyson has taken the idea a large step forward.

He foresees the time when not only the asteroids but also the comets are pressed into the service of humanity. Ventures in astro-engineering can make comets habitable, Dyson has written, and the time will come when humans ride comets through outer space. With such an abundance of space resources available, what species would want to invade an inhabited planet?

The fear of contact is real. But it is not fear that has put interstellar transmission out of style in earth's SETI community today. The real reason is inefficiency. Robert E. Edelson, SETI project manager at the Jet Propulsion Laboratory, explained it this way:

> Where would we aim the signal? Suppose we chose the nearest sunlike star, about eight light-years away. If there just happened to be intelligent life around that star and if they just happened to be listening to the right frequency at the right time with their antenna pointed in the right direction, they would detect us eight years from now, and if they immediately replied, then we would receive their signal eight years after that. Now, that's an extremely unlikely scenario, and yet it would take sixteen years to receive a response.

Or as John Billingham, a SETI leader at the Ames Research Center puts it, if the civilisation is 800 light-years away, it would take 1600 years to get an answer. Those numbers indicate that sending signals doesn't make sense, at least in the present state of affairs. The idea of sending signals is far from dead, but it is dormant. For the time being, the big push in SETI is to get some major listening programme started. To listen on any large scale money is needed – government money. It is the need for money that is the major shaping force in SETI today.

CHAPTER ELEVEN

Strategies

Some time in the early 1970s, the field that had called itself CETI began calling itself SETI: Communication with Extraterrestrial Intelligence became the Search for Extraterrestrial Intelligence. The explanation for the change in the title was that 'communication' implied two-way messages, and that the stress in

SETI was on detecting signals, not sending them. There is nothing untrue in that explanation. But there was another, more subtle reason in the background. The change in acronym also marked a change in the point of view of most people in the field: a ripening, a growing maturity, a reining-in of some of the wilder and more expensive ideas. It was no coincidence that the change occurred in the years when CETI (or SETI) changed from a purely theoretical exercise to a discipline that had gained almost complete scientific acceptance and had begun to compete with other disciplines for a limited supply of money.

Project Cyclops

Perhaps the best way to illustrate the change is to describe two proposed plans for the detection of interstellar signals that were made just a few years apart. The first, Project Cyclops, was published in 1971, when the field was still called CETI. The second study became public in what was called a prepublication form in 1977, and is titled simply *The Search for Extraterrestrial Intelligence*. Both plans were formulated after a series of workshops on various aspects of interstellar communication. Many scientists participated in both studies, and many of the statements in the 1977 report were taken bodily from the Project Cyclops publication. But there is almost no comparison between the programmes recommended in the two plans.

In scope, duration, and expense, Project Cyclops ranks with Project Apollo, which put men on the moon at a cost in excess of $20 billion. A couple of sentences from the report gives an idea of its scale:

> From the air, the final Cyclops system would be seen as a large central headquarters building surrounded by an 'orchard' of antennas ten kilometres (6.25 miles) to ten miles in diameter and containing 1000 to perhaps 2500 antennas . . .
>
> Cyclopolis, the community where the system staff and their families live, might be located several miles from the array, perhaps behind hills that provide shielding from radiated interference. Transportation to and from could be by bus at appropriate hours. Alternatively, the central headquarters might be made large enough to provide the necessary housing, stores, schools and so on. There would be ample room between the antenna clements for playgrounds and recreation facilities . . . (See Figures 5 and 7.)

The 243-page report on Project Cyclops envisioned a long-term programme to build the orchard of antennas. Each dish would be 100 metres – or 330 feet – in diameter. There would be at least 1000 and perhaps as many as 2500 antennas in the orchard, giving a total antenna surface that would be measured in square miles. Cyclops would start small, with only a few antennas around the central headquarters, but it would grow steadily, with more antennas being built every year. The cost was envisioned at about $600 million a year for ten to fifteen years, a total of anywhere from $6 billion to $10 billion. And since such an array would not be able to scan the entire sky, the report said that two of them might be built, one for the northern hemisphere and one for the southern hemisphere. Operating costs for a Cyclops system would be in the hundreds of millions of dollars a year.

For this, the report said, taxpayers would get a system that could scan the sky 200,000 times faster than Project Ozma. The report, written by Bernard Oliver, said that the comparison is made

> not to disparage Ozma, but to build faith in Cyclops. Ozma cost very little and was a laudable undertaking, bu the power of the Cyclops search system is so enormously greater that we should completely discount the negative results of Ozma. The Tau-Cetacians or the Epsilon-Eridanians would have to have been irradiating us with an effective power of about 2×10^{13} watts (2000 billion watts) to have caused a noticeable wiggle of the pens on Ozma's recorders; 500 kilowatts would be detected by Cyclops.

The report envisioned a four-phase operational scheme for Cyclops. In the first phase, during the planning stage, a 'target list' of stars to be studied would be compiled by using a battery of light telescopes operating under automated control. The telescopes would divide the sky into segments, each telescope recording the visual spectrum of all the stars in its segment. Each star would automatically be classified by spectral group, so that only sunlike stars would be on the list to be scanned by Cyclops. From three to six light telescopes would be needed to prepare the target list, the report estimated.

Then comes the construction period, where about 100 antennas would be built annually for at least ten years. The search for extraterrestrial life would begin as soon as the first few antennas went into operation. 'During the first years, the nearest stars would be searched for both leakage and beacons, and the

techniques for doing this efficiently would be developed and tested,' the report said. 'Then, during the remaining construction years, the search would be carried further into space.' Lest the pace be thought slow, remember that the report envisaged a scan of 15,000 stars a year, with an observation time of 2000 seconds per star. At the end of ten years, when the system was fully fledged, the early stars probably would be restudied, using the full capability of Cyclops.

Now we are into phase three, 'total search with the complete system'. The first one or two scans looked at stars as distant as 500 or 700 light-years. Now the search would be extended out to 1000 light-years. Cyclops might also be used as a beacon, sending out messages for a full year. In that case, the nearest thousand sunlike stars would be studied for possible responses.

Carefully stating that the four-phase scheme is a 'worst-case' plan, based on the assumption that no signal would be detected, the report says that the fourth phase would be a pause for regrouping. The possibility that the basic thesis of SETI will have been disapproved by work with Cyclops is discounted. Instead, the report says that 'the decision to build a long-range beacon must be faced' – and, by implication, that the inevitable choice will be to build a beacon. Cyclops would then return to its search while the beacon would send endless messages to the stars; both would be fully automated. There is no indication of an end to the search or the transmissions, but rather a hope that 'because other races have entered a Phase IV, this phase may never be reached'.

Needless to say, Cyclops would be more than just a tool for SETI. It would also be a valuable instrument for astronomical studies. The report mentions several possible studies. Cyclops could serve as antenna for transmissions from spacecraft sent to explore the outer solar system; it could, the report said, allow spacecraft to transmit from distant Uranus with the same efficiency as today's transmissions from Mars. As a radar facility, Cyclops could map every major object in the solar system, including the moons of Jupiter and Saturn. As a radio telescope, Cyclops would improve observations by a minimum of tenfold over today's capabilities: many more pulsars could be detected; the diameters of distant stars could be measured; stellar motions could be studied with precision.

The importance of Cyclops as a facility for ordinary astronomy has been stressed by several people in the SETI community who are concerned with one major future problem in the field: boredom. If Cyclops were used for SETI alone, it might be entirely

possible for a bright young astronomer to come right out of college into Cyclops, work there for an entire career and leave, grey-headed, half a century later, with nothing but negative results to report. The prospect of having only acres of filing cabinets with detailed information on millions of stars that do *not* have civilisations to show for a lifetime of effort does not beguile the average astronomer. Therefore, it has often been assumed that a facility like Cyclops would either be devoted to ordinary astronomy for a fairly large fraction of its operating time or that most astronomers would serve only a portion of their careers at Cyclops. But as Cyclops was described in the report, its mission was clear: 'The sole intent has been to optimise its performance as an initial detector of intelligent transmissions.'

Cyclops was heady stuff. It made for marvellous newspaper headlines, and it came equipped with an artist's beautiful conceptions of the completed orchard of radio telescopes. It was only if you looked very hard that you could see a few sentences that could be regarded as a disclaimer, a concession that the Cyclops programme was really play-acting. Those sentences came in the introduction:

> . . . Both the extremely preliminary nature of this study and the great uncertainty as to whether a system of this type will be bui't in the reasonably near future force us to emphasise that presently contemplated expenditures in radio astronomy, radio mapping and deep-space communication facilities should be evaluated without regard to the content of this report. It would be extremely unfortunate if funding for any worthwhile projects in this field were to be deferred or reduced because of a mistaken impression regarding the imminence of a Cyclops-like system . . .

So we could say that the Cyclops project is a form of window shopping, the wistful peek at a dream car that a buyer indulges in before going out to buy the sedan that fits his budget. From this point of view, the most valuable part of the Project Cyclops report were the sections that never got much wide public attention, the detailed calculations about the design of the antennas, the receiver system, the transmission and control arrangements, the signal processing. After the publication of the Cyclops report, the SETI community had a solid document full of information ready for anyone with questions about the search for extraterrestrial intelligence.

And perhaps it is only now that the Cyclops proposal looks over-ambitous. At the time – just two years after the success of Project Apollo – the habit of thinking big in space projects was still prevalent. The weight of the big names in the SETI community was behind the Project Cyclops study, and $600 million a year did not seem like so much in the context of the billions spent on Apollo.

Lunar and Orbiting Systems

Certainly the next report on SETI systems was no smaller in scale. This one came from the Stanford Research Institute, which is only a few miles away from Ames and which was paid by NASA to evaluate three systems: Project Cyclops, a Cyclops-type array of antennas on the far side of the moon, and an orbiting SETI system that would be built on earth and deployed in space. The reason for going to the moon or into orbit would be to escape the terrestrial radio signals that have caused so many false alarms in SETI programmes so far. The lunar antenna system would be shielded from the earth's signals by the mass of the moon, while the orbiting system would have a large disc built between it and the earth to act as a shield.

None of these systems would be cheap. Going to the moon is the most expensive alternative, not only because of the high cost of launching the system into space – about $350 a pound according to the Stanford Research Institute estimate, with a total launch cost in the neighbourhood of $25 billion – but also because of the need to maintain a large lunar colony to run the equipment.

Two kinds of lunar systems were considered. One would use an orchard of movable radio telescopes similar to those envisaged for Cyclops. The second would use Arecibo-type fixed antennas that would be built in lunar craters. Since the moon has a large number of craters of all sizes, the lunar SETI system could either use one enormous dish fitted into a large crater or several smaller antennas in lesser craters. The cost of building the antennas woud be much lower on the moon than it would be on earth, because the moon's low gravity – one sixth that of earth – eliminates the need for massive support structures. The study found that the cost of Arecibo-type lunar antennas was very much lower than a Cyclops-type moon system because of the lower construction costs.

The orbiting system came in at an even lower cost. For a major SETI programme, going into space is more efficient than going to the moon. In fact, the Stanford Research Institute study found that a SETI system in space could actually cost less over the long run than an earth-based Cyclops system if the number of advanced extraterrestrial civilisations is relatively small – fewer than about 10,000 civilisations in the galaxy.

The reasoning runs like this: if there are very many advanced civilisations in the galaxy, a signal from one of them could probably be detected in a relatively short time using only a small orbiting system; by 'small' we mean an antenna whose surface is about half a square mile in area. But if advanced civilisations are uncommon, a long search with a much larger antenna array will be needed. The major cost of any orbiting antenna system, large or small, is the cost of research and development, the design of the system, and the construction of the very elaborate rockets and life-support equipment needed to build something big in space. In short, if you decide to build an orbiting SETI antenna, you might as well spend the little bit extra needed to build a big one, if you assume that the search for signals will go on for a long time. 'For the very large systems that would be required . . . space systems are actually cheaper than earth-based systems,' the report said. 'Cheap' means $9 billion, in 1976 dollars.

The space system would have a 'maypole' design, something like a giant umbrella. 'It consists of a long central column hub, a rigid outer rim, and a system of cables [spokes] that tie the hub and rim together. A spherical mesh dish is suspended inside the "wheel" to form the reflector.' Think of it as an umbrella whose diameter would be about two miles. The different parts of the antenna would be manufactured on earth and put together in orbit in the form of a closed umbrella – the antenna surface folded down around the central column. When the antenna system was placed in an appropriate location, the umbrella would be opened, so that the antenna surface would be aimed in the desired direction, towards the stars.

The most likely spot in space for a SETI system is one of the Lagrange points in the earth-moon system. A Lagrange point, named for the eighteenth-century French mathematician who first described the concept, is a point in space that defines an equilateral triangle (one with equal sides and angles), with the earth and the moon as the other two points. Lagrange developed the idea through observations of some asteroids that had an unusually stable relationship with Jupiter. A spacecraft, or an

antenna system, placed in one of the earth-moon Lagrange points, would be equally stable relative to the earth.

Picture an antenna three miles in diameter floating at a Lagrange point. Smaller umbrellas of the same design would float above it, attached by booms, to gather signals from space and feed them to the antenna. To prevent interference from radio sources on earth, a shield would have to be placed between the antenna and earth. Without going into great detail, the Stanford Research Institute report said the that shield would have to be about six miles across, twice the diameter of the antenna itself. (See Figure 6.)

The Business of NASA

When an idealised project begins to assume tangible form, differences of opinion are likely to appear. So it is with SETI. Discussions showed that the SETI community was less enthusiastic about an orbiting system than NASA planners were. NASA's business is space projects, and an orbiting antenna is a major space project; something that could keep aerospace engineers working for years. The Space Shuttle, which is planned as the space workhorse of the 1980s, can easily move large quantities of material into earth orbit. But a new vehicle would be needed to move that material – maybe 8000 tons of it – out of earth orbit to the Lagrange point to construct the space antenna. NASA would like nothing better than to build a 'space tug' to do that job. The people who put men on the moon love the thought of space tugs and three-mile-diameter orbiting antennas.

SETI people are usually supported by NASA funds and often work for NASA, but they are not NASA people in the strictest sense of that phrase. SETI is primarily science – not entirely, as we shall see, but primarily. The major interests of most NASA people is hardware. Anyone who has been in the Vehicle Assembly Building at the Kennedy Space Center in Florida can understand the fascination of space in terms of hardware. The VAB is the world's biggest box – fifty-eight storeys high. It was used to hold the world's biggest scale models, the equipment that sent men to the moon. Standing in the building and looking at the Saturn V rocket, which stood as high as the Statue of Liberty, one could understand the joy that comes from building a 1:1 scale model of the world's biggest rocket. You could understand why Apollo 17, the last moon mission, was launched at night. The men who had

built the machine wanted to see what it would look like at night. (It looked like a giant, cold arc lamp, yellowish-white.)

In the middle of the 1970s, signs of friction between the Ames Research Center and the Jet Propulsion Laboratory began to appear. Most SETI work had been done at Ames, although not all SETI people, by any means, were stationed at Ames (Cornell University, which has both Drake and Sagan, is a major SETI centre in the East by virtue of their presence). JPL did some work on extraterrestrial intelligence, but not nearly as much as Ames. In the boom times of the 1960s, JPL was kept quite busy by other projects.

Then came the shrinkage of NASA funds in the 1970s. Competition for the limited amount of money that was available developed quickly. In that competition, JPL was a major winner: it was given complete supervision over the American programme of planetary exploration. Ames, which had a number of significant planetary missions until then, was phased out of the planetary exploration programme entirely.

So far, the division of responsibilities seemed to be clear: planetary exploration for JPL, SETI for Ames. But it did not remain clear. As the 1970s wore on, a growing interest in the field of SETI began to be evident at the Jet Propulsion Laboratory. In fact, when the time came for the SETI community to ask for official funding from the space agency, two separate proposals were presented to NASA: one from Ames and one from JPL.

Officially, the two programmes were presented as complementary halves of a unified effort. However, at NASA headquarters, the Ames plan and the JPL plan were viewed as rivals for whatever money would be available for SETI in the 1979 fiscal year budget. From the beginning, it was obvious that either JPL or Ames would be funded, but not both.

The two plans presented quite different strategies in the search for extraterrestrial intelligence. The one thing they had in common was a de-emphasis of the think-big approach of Project Cyclops, for practical reasons. In the ebullient 1960s, it was easy to talk about projects that would cost tens of billions of dollars. In the cramped 1970s, that sort of talk was frightening and repellent to the administrators and legislators who drew up budgets and voted on appropriations. To a large degree, the SETI community found itself explaining away Cyclops as a mere adventure in speculation, a pullback that was regarded as a necessity for getting any funding for a search for extraterrestrial signals.

'We have explained to everyone that Project Cyclops was a long-term study that was done some time ago,' John Billingham of Ames said in a 1977 interview. 'Since that time, everyone has gone back to square one, to fundamental questions. The outcome is clear. The way to start the programme is at a much more modest level than Cyclops envisaged, to use existing radio telescopes and work at a very modest level before contemplating the business of getting into a dedicated system. [By that he meant a system totally dedicated to SETI.]

'Cyclops has sort of been pushed into the future. Cyclops is a big master plan that might be adopted some day. We're trying hard now to explain to people that nobody is proposing to build Cyclops. We are at a stage well before that.'

SETI Grows Up

You could put it another way: SETI was growing up. It was becoming more than a symbolic effort that a few enthusiasts would undertake only to prove that it could be done, more than a fantasy that could be outlined with no thought to time or money. The narrowing of objectives that was evident between the Cyclops report of 1971 and the SETI report of 1977 might have seemed disappointing to some, but it was really a sign that SETI was coming of age. The 1977 report was talking about a few million dollars now, not tens of billions of dollars in the misty future. It had to make a hard, businesslike case for an appropriation in a budget where money was not easy to come by.

What SETI lost from this approach was charm – the sort of charm that was lost when Apollo landed on the moon and ended all speculations about the composition of the lunar surface, or when Viking landed on Mars and substituted data for imagination. The great fascination that SETI holds for most people is a matter of charm. SETI has been Little Green Men and Unidentified Flying Objects and Chariots of the Gods and Dyson spheres and Kardashev civilisations and space probes and all the rest. Now it has come down to a matter of dollars and cents, of offering specific programmes that give the maximum chance of finding another civilisation at a reasonable cost. The loss of charm is regrettable but inevitable. UFOs retain charm because they are impossible, the stuff that dreams are made of. SETI is losing charm because it looks more and more like a real-life enterprise. The numbers that go into SETI calculations – the

distances of the galaxy, the times of stellar evolution – indicate that contact will not be made in one quick, romantic burst of effort. SETI must settle down to the long grind.

The new 1977 SETI report reads like a prospectus. It is backed by two years of workshops covering every aspect of extraterrestrial intelligence, from star formation to electronic equipment. The participants in those workshops included not only all the big names in SETI – Morrison (who served as chairman), Bracewell, Drake, Sagan, Oliver, Billingham, and many others – but also a number of influential members of the American astronomical community. The report, edited by Morrison, Billingham, and John Wolfe of Ames, sets forth what is described as a 'consensus', with four main conclusions:

(1) It is both timely and feasible to begin a serious search for extraterrestrial intelligence.
(2) A significant programme with substantial potential secondary benefits can be undertaken with only modest resources.
(3) Large systems of great capability can be built if needed.
(4) SETI is intrinsically an international endeavour in which the United States can take a lead.

Note the emphasis on practicality. SETI is a serious scientific subject. A programme can be started with 'modest resources' – a few million dollars, not many billions – and it will have 'substantial potential secondary benefits'. Yes, large systems like Cyclops can be built – but not now. Finally, if the United States takes the lead, other nations will help share the load: 'We can and should expect growing co-operation with investigators from many countries, both those already displaying interest and activity, as the Soviet Union and Canada, and others whose interest would grow.'

All these statements are selling points, not only for a money-conscious Congress but also for the NASA administration and the astronomy community. Not all astronomers are keen on SETI; many of them regard it as a quixotic enterprise that will not add much to our knowledge. Shortly after the report began to get publicity, Jesse Greenstein of the California Institute of Technology, one of the most respected figures in American astronomy and a member of the committee that prepared the SETI report, was quoted as saying, 'I'm not entirely sure I either like or approve of the enterprise.'

Greenstein's doubt was based on scientific questions, but

money is also an issue. Astronomy has largely become a government-funded endeavour, and government money for science has tightened in the 1970s. Money that goes to SETI comes out of someone else's budget, directly or indirectly. Hence the stress in the 1977 report on the usefulness of the proposed SETI programme for all astronomers: 'As soon as a dedicated SETI facility achieves either a sensitivity or spectral coverage not found in present radio or radar astronomy instruments, it becomes a uniquely useful tool for research in these areas. An almost continuously increasing spectrum of applications exists as the SETI facility is expanded in scope.' And hence the emphasis on low initial cost:

> A large, expensive system is not now needed for SETI. If we but equip existing radio telescopes with low-cost state-of-the-art receiving and data-processing devices, we will have both the sensitivity to explore the vicinity of nearby stars for transmitters similar to earth's, and to explore the entire galaxy for more powerful signals . . It will be timely to consider whether to proceed with a larger-scale programme after this earlier effort has shown us more accurately what might be involved.

Both the JPL and the Ames proposals fit those general guidelines, but the differences between them were basic. As Robert Edelson of JPL explained it, 'They [Ames] want to look at stars that are likely candidates for having life. If you do that, you can get very good sensitivity. The approach we are taking is to look at the entire sky to try to detect weak signals. In our state of knowledge, we don't feel that there is any particular preference for selecting stars to be scanned.' In other words, the old hands at Ames proposed to push ahead with the same strategy that had begun with Project Ozma: looking at specific stars and studying very narrow bandwidths. By contrast, the relative newcomers at JPL had a strategy resembling the Soviets': looking at the whole sky over relatively broad bandwidths to detect extremely powerful signals.

Both the Jet Propulsion Laboratory and the Ames Research Center said they would use much of the NASA money to build an innovative piece of electronic equipment called a signal processor, which would make the search for an intelligent signal more efficient than ever before. The signal processor would do its work after the antennas collected the radio waves. The Jet Propulsion Laboratory proposed to use rather small antennas: an

85-foot dish and a 30-foot dish in the desert at Goldstone, California, both part of NASA's Deep Space Network, and a 14-foot horn reflector. JPL proposed to look methodically at a large portion of the sky in all the frequencies from 1000 MHz to 25,000 MHz, taking slices of 300 MHz at a time. (For example, it might look first at the range from 1000 to 1300 MHz, then at the range from 1300 MHz to 1600 MHz, and so on.)

The signals from the antenna would go to pre-amplifiers that would separate signal from noise. Advances in electronic equipment will allow JPL to build pre-amplifiers better than any used before in SETI, yielding a cleaner signal to analyse.

After the pre-amplifiers comes the signal processor. It is designed as one of the wonders made possible by the recent explosion in micro-electronics. Electronics engineers have been able to squeeze more and more components on a semiconductor chip. A single chip that can fit on a fingernail now has the power of a computer that would have filled a room in the 1960s. These chips are cheap; computer central processing units by the barrelful now cost about $20 a chip. (One hesitates to quote a price because any quote is too high by the time it gets into print.) Using such chips, JPL can put the 300-MHz-wide signal that emerges from the pre-amplifier through a processor that will look at 100 million different frequencies simultaneously for the faint, coherent signal that could be a message from another civilisation.

The JPL scheme would look at about 80 per cent of the sky – all that can be seen from the Goldstone site – one patch at a time. Edelson calculates that the search will take five years and will take in perhaps 100 million sunlike stars. Most of the data will be thrown away because, as Edelson says, 'We could fill the Library of Congress with books of this output in just a fraction of a day.' Anything that looks interesting will be retained on magnetic tape – and 'interesting' means signals of astronomical importance as well as suspected messages from other civilisations. Like the ongoing Ohio State scan, the JPL scan will single out a number of objects in space that are worthy of further study by astronomers. As Edelson explained, 'Even negative results will be significant.'

The Ames strategy is more conventional. (It is remarkable to think that SETI is now old enough so that a strategy can be described as 'conventional'.) It would use very large antennas – the 1000-foot dish at Arecibo, the 175-foot antenna at Ohio

State, a similarly large but as yet unchosen dish in the Southern Hemisphere, either in Chile or in Australia. It would look at carefully selected stars, all of the 500 sunlike stars within 80 light-years of the earth. It would look at the well-established frequencies in the water hole. And it would look at slivers of the water hole only one MHz wide. Its signal processor, like JPL's, would analyse one million different channels in the signal. But while JPL would be looking at channels 300 MHz wide, Ames would examine individual signals only one hertz wide – roughly the width of the carrier band used by a television station.

In an initial search, Ames would look at each star for ten or fifteen minutes. Since its search would use only a small part of the operating time of the radio telescopes, the entire search would take between three and four years. If the search was negative, Ames had plans for going back to look at different frequencies, perhaps using a more advanced signal processor that could search one billion channels at a time.

When the federal budget appeared in January 1977, JPL was the winner. The budget proposed $2.1 million as a start for a seven-year, $14-million broad-band search of the sky. Ames got nothing but a statement that its plan would get serious consideration in the future.

The people at Ames were unhappy and resentful. 'Ames has been working on this for nine or ten years,' one of them said. 'We have done a lot of things in this field. JPL is just a latecomer.'

More than that, Ames viewed the JPL plan as having very little value for SETI. People at Ames could pull out charts to demonstrate that the JPL programme could detect only overwhelmingly strong transmissions from relatively nearby civilisations. From the Ames point of view, NASA supported the JPL plan not because of its value to SETI, but because the work done by JPL would help refine the operations of the Deep Space Network.

Mark A. Stull of the SETI programme office at Ames put it this way: the Ames listening programme could pick up signals from the most powerful transmitters now operating on earth – the BMEWS military radars – at a distance of ten light-years. 'We could clearly detect the earth at ten light-years,' Stull said, 'and if the earth had a lot of transmitters just slightly more powerful than the majority now operating on earth, we could see it out to twenty-five, fifty, a hundred light-years distance.' By contrast, the JPL listening programme is fifty times less sensitive than Ames's, Stull said. As Charles A. Seeger of Ames

put it: 'They [another civilisation] would either have to have incredibly powerful transmitters, using planetary-size energy sources, or they'd have to know where we are to aim at us,' in order to be detected by JPL's antennas.

SETI: Soviet Style

Nevertheless, the JPL proposal did win the first round. That victory is less surprising if we look at the only other national SETI programme now going, that of the Soviet Union. The Soviets seem to be following the same approach as the United States has chosen – they have started with a low-sensitivity listening programme but have plans for an Ames-like system in the future.

In 1975 the journal *Soviet Astronomy* printed a report from the USSR Academy of Sciences Board of the Scientific Council on the Radio Astronomy Problem Area which included the statement, 'Efforts to detect extraterrestrial civilisations should proceed smoothly and systematically, and should extend over a prolonged period of time . . . It would be a great mistake to build a programme in contemplation of rapid and easy success.'

The Soviet report outlined two instrumentation projects. The first, running from 1975 to 1985, consists of the existing ground-based system for continuous monitoring of the entire sky, two satellites that would also be used for continuous, wide monitoring and a scan of nearby galaxies using relatively inefficient antennas. The Soviet strategy thus clearly resembles the JPL plan, except that the Soviets favour an even broader-gauge approach. If the earth is being bathed in powerful signals from an extremely advanced civilisation, the Soviets could be the first to detect it. The influence of Kardashev can be seen in this approach. The Soviets are serious about the possibility that Type III civilisations exist. Their plan says that 'the possible discovery of probes sent from extraterrestrial civilisations and now located in the solar system or even in orbit around the earth warrants particular attention'. It also includes a proposal to search for 'thermal radiation inherently emanating from large-scale works of engineering that may have been constructed in circumstellar space', a description that could fit either an advanced Kardashev civilisation or a Dyson sphere. Such speculative ideas do not get much stress in the proposals of American astronomers, who want to avoid the accusation that they are dealing in science fiction, not science.

The second part of the Soviet plan, running from 1980 to 1990 (and thus overlapping with the first project), is slightly vague. But it does resemble some of the advanced American projects. It calls for:

> (1) A satellite system continuously monitoring the entire sky and equipped with antennas of large effective area.
> (2) A system of two widely spaced stations having large (effective area about one square kilometre) semi-rotatable antennas for synchronised reception, searches for signals from specific objects, and analysis of selected sources.
>
> These instrumentation complexes could be used not only for CETI [the Soviets still use the old acronym] work but for a variety of important astrophysical problems.
>
> In addition, additional parts of the programme could be carried out with other radio telescopes in conjunction with the plans of radio-astronomy institutions (sky surveys, investigations of peculiar sources, and so on).

Even with its careful committee-written prose, there is more of the wild blue yonder in the Soviet report than in the latest American proposal. Part of that could be attributed to the Slavic temperament. Soviet science has always been rather open to what could be called borderline concepts: extrasensory perception, for example, has received more serious attention from the Soviet establishment than from ours. Robert Toth, a correspondent for the *Los Angeles Times*, was detained by the KGB for several days in 1977 for receiving documents from a Soviet ESP researcher. It is known that the Soviet military looked carefully at ESP for some time before concluding that it is worthless for military purposes.

In addition, the fact that Soviet budgetary decisions are made by small groups of individuals, rather than by the large groups of legislators, working in the glare of publicity, who approve the United States budget, means that an off-beat idea can get somewhere if only one or two key individuals are convinced of its worth. As the American SETI community waited nervously in late 1977 for the reaction first from NASA headquarters, where the agency's budget was being prepared; then from the White House, where the NASA budget would be pruned; and finally from Congress, where the proposed budget would be put through the congressional mill, its members might have yearned for older days, when science did not depend so completely on government.

In times gone by, an astronomer who needed the equivalent of the $20 million that is being asked for the American SETI programme would have gone to a sympathetic millionaire, not the government. Now such a proposal must meet the needs of consensus calls for a whole-sky, low-sensitivity study, not an effort to zero in on specific stars which could harbour civilisations that might be trying to get our attention.

And even that limited programme is in trouble. The vision that exists within the SETI community is not shared by many members of Congress. In 1978, Senator William Proxmire announced that the SETI programme would get one of his 'Gold Fleece' awards which Proxmire established to ridicule government-funded scientific programmes which he regards as absurd. More important, both the Senate and the House subcommittees which considered the SETI request cut it drastically, from $2.1 million to $700,000. The cut amounted to an indefinite postponement of the proposed sky search. It was the most disappointing reception possible.

CHAPTER TWELVE

Futures

Maybe there is nothing out there.

If there is something, maybe we can never detect it.

Those two propositions are the dark side of the search for extraterrestrial intelligence. The pessimistic view that we are, in fact, alone in the galaxy is rarely discussed at length because people don't want to hear it But the cause against SETI is made occasionally, and it must be considered.

One way to be pessimistic about life elsewhere in the universe is to attack the principle of mediocrity. If the earth is somehow unique, then the human race might either be the only intelligent species in the galaxy, or it might be one of a very few intelligent species that are so distant from one another that contact is effectively impossible.

The principle of mediocrity can be questioned at a number of points. For example, there is the assumption that in most planetary systems, at least one and probably more planets will be

hospitable to water-based life. But in the solar system, we see that Venus cannot support life because of a runaway greenhouse effect and that Mars is at best a borderline habitat because it is too small to maintain an adequate atmosphere. As for earth, there are indications that a disturbingly small alteration in some of this planet's characteristics could make it quite unsuitable for life. For example, it has been estimated that displacement of the earth only six million miles closer to the sun would result in a runaway greenhouse effect. The earth would then receive so much solar energy that all its water would vaporise. Without liquid water, carbon dioxide would not combine chemically with surface rock, but would remain as a gas. Both water vapour and carbon dioxide absorb infra-red radiation powerfully, so that the earth would become the hell that Venus is.

The Doubts

Then there is the SETI assumption that an intelligent species more or less like the human race will arise on most life-supporting planets. As we have seen, George Gaylord Simpson, one of the best palaeontologists in the world, has expressed serious doubts about the inevitability of the evolution of intelligence. Some recent discoveries about the evolution of the hominids – the primates that evolved into *Homo sapiens* – indicate that our arrival on earth was the result of a particular combination of circumstances involving geography, climate, and animal evolution.

As the present picture runs, small primates had evolved from an ancestral mammalian stock in a dense forest that covered Europe, India, East Africa, and the Middle East. About 12 million years ago, for reasons that are not well understood, global temperatures began to drop and the thick forest was partly replaced by open grasslands. A few primates ventured out on to the open savannah, where evolutionary pressures led them to develop upright walking, dexterous hands, and all the other capabilities that brought about the evolution of the human race.

But suppose the climate had not changed just when it did. If the global cooling had occurred a few million years earlier, there might not have been primates ready to explore the new evolutionary opportunity. If the earth had not cooled at all, the forest-dwelling primates might have stayed in their secure ecological niche, without the need to develop towards human capabilities.

Another possibility that got a good deal of attention at one time centres on the role of the moon in terrestrial evolution. The earth-moon system is decidedly unusual in the solar system; no other planet has a satellite that is so large by comparison. The moon causes tides. It has been suggested that if there were no moon, the absence of tides would make it more difficult for marine animals to move out of the ocean to dry land. Therefore, if intelligence did evolve on a tideless planet, it would be the sort of intelligence postulated for the dolphins – that is, a non-technological, water-dwelling intelligence. According to this train of reasoning, a moonless planet could not have an intelligent species with which the human race could communicate.

It is an interesting thought, but one which most scientists now reject for at least two reasons. Biologists are not at all certain that large tides are needed to help sea animals make the transition to dry-land living. And if they are needed, the tides caused by the gravitational pull of the sun could well be enough. The moon's gravity is responsible for only two-thirds of the earth's tides. If there were no moon, the earth would have tides one-third as high as the ones we have now. So the uniqueness of the earth-moon system does not mean that the evolution of an intelligent, technological species on this planet is a unique event.

Arguments against the principle of mediocrity are almost endless. But there is a single counter-argument that is remarkably effective: an argument based on the vastness of the universe and the enormous number of stars like the sun. With so many stars and so many billions of years, the counter-argument runs, it is highly improbable that the sun should be alone in having a planet that supports intelligent life. It is hard to believe that in all the roles of the cosmic dice, only one throw has been successful.

However, the most effective argument against the optimistic view of SETI is based on cosmological numbers. The pessimists say that the vastness of the universe is such that there is an almost vanishingly small chance of two intelligent species being close enough in both time and space to establish communications with one another.

As we have seen, 'travellers' such as Bracewell, Kuiper, and Morris have used this argument to support their belief that space probes, not radio telescopes, are the most appropriate method for interstellar communication. The scenario that the pessimists write is always the same. It hinges on the improbability of two civilisations being at the same technological level at just the right

time for both of them to be ready for interstellar contact. Time and space, the pessimists say, are both against SETI. D. R. Bates, a physicist at Queen's University in Belfast, Northern Ireland, has expressed his scepticism several times, as in a paper published in 1974 in *Nature*:

> . . . the number of communicative civilisations in the galaxy is at most 1000, from which it follows that the likely distance to the nearest is at least several thousand light-years. Perhaps most serious, the value of the . . . time before contact between a pair of dedicated radio telescopes is likely to be made becomes 10,000,000 years . . . the prospect is unpromising.

But even if two civilisations that can communicate are relatively close to each other by galactic standards, we can still outline a pessimistic scenario that ends with no contact. Assume that the other advanced civilisation is only 200 light-years from earth – an optimistic assumption in SETI. Since the earth has just arrived at the capability of extraterrestrial communication, we can assume that the other civilisation is ahead of us. Let us say that it is at least 1000 years ahead of us and that it has been working at interstellar contact for 500 years.

Civilisation X, as we can call it, has a list of promising stars within 1000 light-years of its home planet, and the sun is on that list. Five hundred years ago, Civilisation X pointed its first signal-seeking SETI system at the sun and heard nothing. Four hundred years ago, the effort was repeated. Again nothing. Since then, Civilisation X, whose prosperity grows as its technology advances, has surveyed the earth at ten-year intervals, each time for several days. All the results have been negative. They will remain negative for another 150 years or so, until earth's radar and television transmission bubble, travelling at the speed of light, reaches Civilisation X.

Will it still be listening? That question is being debated right now in the planetary congress of Civilisation X. Even though the planetary system of Civilisation X is wealthy, some legislators are murmuring that the money which has gone into this centuries-old search for extraterrestrial intelligence could be better spent elsewhere – on an expansion of the asteroid-mining programme, for example.

But a pro-SETI legislator is rising to speak. More time is needed before the programme is abandoned, the legislator says, pointing out that Civilisation X began sending interstellar signals 150 years ago. An answer to those signals might arrive any day, the legislator says, and it is worth waiting for.

The hypothetical signal will arrive at earth in fifty years. Of course, it will fall on earth for a limited time only; each promising star is allotted a few days' beacon time. If the earth is listening, and if the message is received and understood, headlines will proclaim the first extraterrestrial contact. A return signal will be sent at once. It will arrive at Civilisation X in 200 years. Will Civilisation X still be listening then? Highly unlikely, say pessimists, drawing on their knowledge of the short attention span of terrestrial legislators.

In an article in the magazine *Astronomy*, Gerritt L. Verschuur – who, if you remember, conducted the first search for extraterrestrial signals after Project Ozma I – concluded that SETI is a forlorn hope:

> It appears impossible for short-lived civilisations to contact each other, while long-lived civilisations are hundreds of light-years apart. Given man's present penchant for impatience, we can hardly claim to be communicative on the time scale required for interstellar discussions.
>
> The inevitable conclusion that evolution never stops leads to the assumption that L (the lifetime of civilisations in Drake's formula) is a small number. If this is the case, it follows that we are effectively alone in our little corner of the Milky Way. Civilisations light-years away might as well not exist. We shall never contact them; we will never find the needle in our interstellar haystack.
>
> We are alone in space!

The Faith of SETI

Against this mass of pessimistic numbers, the SETI community musters a curious weapon: faith. To be sure, it is a scientific faith, bolstered by laboratory data, technical formulas, and the like, but it is faith nevertheless. A number of scientists have pointed out that belief in such borderline subjects as UFOs, extra-sensory perception, and Kirlian photography can be described as an effort to substitute new scientific certainties for the old religious certainties that science has undermined. It has often been remarked that ufologists believe that the earth is being watched by beings from the heavens who have remarkable powers and who could save humanity from its present plight; the conclusion of the hit movie *Close Encounters of the Third Kind* certainly emphasised the religious tinge to the UFO belief. Erich von Däniken himself has said that religious uncertainty is a major reason for the success of his books, which describe the purported ancient astronauts as 'gods'. It must be noted that the same sort of faith is at the root of SETI.

If a SETI programme on earth is to succeed in making contact with another civilisation, that civilisation will have to be very advanced, in ways that go far beyond its technology. It will have had to make a commitment to an extremely long-term effort at extraterrestrial communication. To fulfil that commitment, the civilisation must have entered a prolonged period of affluence. Its leaders must have the vision to realise that success at interstellar contact requires unending vigilance and the devotion of a growing share of the civilisation's resources. As for the technology of the civilisation, it would have to be incredibly advanced by comparison with the earth's present capabilities to be able to transmit a beacon that the earth can receive – for it must be remembered that similar beacons would have to be sent towards many thousands of stars.

It might be an exaggeration, but not a great one, to say that the combination of technical mastery and wisdom attributed to such a civilisation are almost godlike by the standards of today's squabbling, unhappy human race.

But even leaving any tinge of religion out of the discussion, the belief that such a civilisation could exist is an act of faith in humanity. It is belief that a civilisation like ours can break through all the problems that now threaten not only to bring our technological society to its knees but also to destroy the human race. The SETI community wants the human race to assume that such a positive breakthrough has taken place elsewhere in the galaxy. We are asked to spend first millions and then billions of dollars because of that assumption. It is stated in almost so many words by people in SETI that contact with such a civilisation is almost certain to transform mankind.

'Underlying the quest for other intelligent life,' Bernard Oliver wrote in the Project Cyclops report, 'is the assumption that man is not at the peak of his evolutionary development, that in

fact he may be very far from it, and that he can survive long enough to inherit a future as far beyond our comprehension as the present world would have been to Cro-Magnon man.'

A Vision of the Future

And remember Frank Drake's vision of the future, expressed in an issue of the magazine *Technology Review* that was dedicated to Philip Morrison: it is the year 1996, and after years of listening, an orchard of antennas in the Mojave Desert detected 'a message in binary code, a message that will be received for a year before the scientists understand the format of the message and recognise it as the song of people who have been alive, every single one of them, for a billion years'. The message, Drake's story goes on, carries the information that will make immortality possible for human beings.

> As never before, the people of earth now hold their destiny in their own hands. Should they adopt a life of immortality, thus causing a shattering transition in human life so great that its consequences are hardly predictable or imaginable? Or should they cling to death as well as their heritage of all that is good in human life?

Drake's story ends tantalisingly with no answer to his questions:

'It is the year 2030. The last humans remaining on earth . . .'

This is a vision literally of death and transfiguration, an unusual blend of science and something that can be described only as religion. We could draw a parallel by pointing out that the Christian religion envisions mankind's fulfilling its destiny in the heavens. So does SETI, occasionally in a manner as fervid as that of early Christianity. The young people who crowd into lecture halls to hear the latest negative results of searches for extraterrestrial intelligence are not interested in electronic hardware and budget requests nearly as much as they are in the vision of the future that SETI makes possible – a vision in which technology enables mankind, in the words of Carl Sagan, to 'break the shackles of earth'.

Space Colony

A plan for getting mankind off the earth and into space already exists. It was developed in the early 1970s by Gerard K. O'Neill, a professor of physics at Princeton University, and has been

refined in a series of workshops and studies since then. O'Neill believes that a majority of the human race could be living in space colonies in just a few decades. It is a technological vision that has been enormously popular on college campuses, but decidedly less so among the decision makers at NASA. The very least that can be said about O'Neill's space-colony plan is that it is a dazzling proposal to leap over all of the problems facing mankind.

The plan would be possible only with regular flights of the Space Shuttle, a NASA spaceship that is scheduled to make its first orbital flight in 1981. The Shuttle will be a re-usable launch vehicle, capable of putting up to 29 tons of payload into earth orbit with each mission at a much lower cost than has been possible until now. The Shuttle is a two-stage system. The first stage consists of rockets that put a winged vehicle into orbit; the rockets then parachute to earth to be used for future launches. The orbiter places its payload into orbit around the earth and flies back to make a landing at a specially prepared strip at the Kennedy Space Center in Florida.

For the first step in O'Neill's space-colony plan, several dozen Shuttle flights would put 2075 tons of payload into orbit. Most of that payload would consist of Shuttle fuel tanks, which would be ground up in space to be used as an odd kind of fuel for a distinctively different kind of propulsion system called a mass driver.

Picture the mass driver as a slingshot. But instead of using rubber bands, the mass driver would have a series of buckets into which coils of superconducting wire are built. (A superconductor is a material in which an electric current, once started, goes on virtually forever. Superconductivity occurs only within a few degrees of absolute zero.) The buckets would be suspended above an aluminium track by the interaction of the current in the coils with the metal of the track. Electrical pulses can quickly accelerate the buckets to extremely high speeds. In space, the buckets would throw the ground-up material of the Shuttle's tanks backwards and would thus achieve thrust. In a leisurely, spiralling journey, the 1100 tons of ground-up tank would be used as fuel to place a 730-ton payload in orbit around the moon. The mass driver would then go back to earth orbit, ready to make the round trip again.

The earth-moon flights would establish a lunar mining colony. But the moon colony would not be an end in itself. It would be only a stepping stone to outer space, which O'Neill regards as

mankind's destined habitation. The trouble with the moon, O'Neill says, is gravity: too much of it to make the shipment of moon minerals to earth profitable (rocket launches are expensive) but not enough of it to keep humans comfortable over prolonged periods. O'Neill believes that fewer than two dozen persons will be needed on the moon to run a permanent mining operation. Setting up that operation, his studies indicate, would require about 2800 tons of Shuttle payload. or about 100 Shuttle flights. Of that total, slightly more than 1000 tons would actually be landed on the lunar surface.

The mass driver itself would be included in the lunar mining operation – in fact, the mass driver would be the key element of that operation. The objective of the lunar mining camp is building a space colony. It would start by processing about 9000 tons a year of lunar rock and would soon reach a capacity of over 600,000 tons a year. Moon rocks contain almost everything needed to build a space colony, O'Neill says. They are 20 per cent silicon – which could be made into solar cells to turn sunlight into electricity – about 20 per cent of a mix of metals, including aluminium, iron, and magnesium – which could be used to build the space-colony structure – and about 40 per cent oxygen, which could be used to supply the space colony's atmosphere.

In the first stage of space colonisation, the relatively small number of people in the space work crews would live in Shuttle tanks that would be converted to living quarters. The tanks in space would be connected by cables and would spin to provide artificial gravity for the inhabitants. The workers in space would be on the catching end of a cosmic baseball game. On the moon, material would be placed in the buckets of the mass driver and would be hurled off towards the temporary space camp. The materials would be caught and assembled into the first space colony suitable for large-scale habitation.

Several studies financed by NASA have produced a picture of that first space colony, which O'Neill calls Island One. It would be located at one of the earth-moon Lagrange points, L5. The first concept called for a torus, a doughnut-shaped space colony. More recent plans call for a sphere – called a 'Bernal sphere' in honour of the British scientist – with a circumference just under one mile, and a population of 10,000. (See Figure 8.) Originally, O'Neill's plans called for Island One to be self-sufficient in food – plants could be grown in lunar soil sent up by the mass driver – but the latest studies say that the colony could be economically

viable even if a large amount of food had to be brought up from earth.

Island One would make money by generating electricity. It could use large islands of solar cells to turn sunlight directly into electricity, or it could use mirrors to focus the sunlight, boiling water to drive turbines. Either way, the electricity would be sent back to earth as a powerful microwave beam. Within a relatively short time, O'Neill says, such space generating stations could supply an important fraction of the earth's electrical generating capacity. A space solar-power station makes more sense than one on earth, O'Neill says, because the terrestrial plant gets sunlight only half the day. The space station can convert sunlight to electricity continuously, doubling its efficiency.

O'Neill and the scientists working with him estimate that Island One could be brought into existence for a cost of about $50 or $60 billion – 'in the range of one Apollo Project, if inflation is taken into account,' O'Neill says – in only ten to twelve years. In its first year of operation, he calculates Island One would return $20 billion in benefits to earth, not only in the form of solar power, but also in other products that are manufactured in space. A good part of the products would be spent building Island Two, Island Three, and so on.

In his book, *High Frontier*, O'Neill pictures an idyllic existence in a space colony. (See Figure 9.) The sphere would turn at two revolutions per minute, providing earthlike gravity for people on the sphere itself. The gravitational force in the sphere would diminish with altitude, so those who climbed the artificial hills would get lighter and lighter. The very centre of the sphere would have zero gravity. The problems caused by gravitational variation would be relatively minor, O'Neill says, as would the drift in falling objects due to the spin of the sphere. Coffee poured from a pot to a cup would drift only a millimetre. However, a pop fly that went up thirty-five feet would land six feet away from the spot that a terrestrial infielder would anticipate, so an Island One baseball game would be an interesting experience.

O'Neill sees great advantages in building a new habitat from the ground up. The inhabitants of Island One would not only have their choice of flora and fauna, O'Neill says ('Perhaps, too, we can find less annoying scavangers than the housefly and can take along the useful bees while leaving behind wasps and hornets'), but would also be able to tailor their climate by controlling the amount of sunlight beamed into the colony. The sunlight would

be reflected into the sphere by large mirrors aimed at tinted windows that would produce a pleasing facsimile of a blue sky.

Island One residents will probably prefer an eternal summer, O'Neill says. If not, a carefully moderated succession of the seasons can be arranged. Later, when the L5 Lagrange point is occupied by a growing cluster of space colonies, it might be possible to provide a specific season in each colony. The space inhabitant who went swimming in a Hawaii-like colony in the morning light might go skiing in an Alpine colony in the afternoon, returning to a suburban-type colony for dinner.

Travel between colonies will be cheap and easy, O'Neill says, because no rockets will be needed. Instead, the spin of the spheres will be used to fling small spacecraft from colony to colony at speeds of hundreds of miles an hour. With an endless supply of energy from the sun, essentially free travel between islands in the sky and all the other benefits of space living, it will not be long before a mass migration from earth begins, O'Neill says. He calculates that more than 7 billion people could be living in space colonies only thirty-five years after the effort starts. And that would be only the beginning. A colony with 10,000 inhabitants could be given a solar electric-propulsion system that would allow them to rove through space almost at will:

> A few decades after the beginning of the human settlement of space there may well be large groups of people roaming the outer reaches of our solar system, on long-term missions with a scientific purpose. Such groups could be connected intimately to the rest of human society by television and radio, so there would be no reason for them to remain isolated unless they chose isolation for reasons of their own.

O'Neill pictures roving universities, roving laboratories, roving communities of all sorts. However, interstellar travel is not in this picture – at least not until the solar electric system could be replaced by a matter-antimatter engine.

Curiously enough, O'Neill is no enthusiast for SETI. The effect of a signal from a more advanced civilisation, he says, will be 'to kill our science and our art', from the culture shock of coming in contact with beings who are so much more advanced than the human race. 'It seems to me horribly likely that as scientists we would become simply television addicts, contributing nothing of our own pain and work and effort to new discovery.' Nevertheless, he does acknowledge that Island One would be 'the ideal place' for a search for extraterrestrial intelligence.

The space-colony proposal is closely related to SETI. What O'Neill has sketched is the first step towards a Kardashev Type III civilisation. In O'Neill's scheme, moon mining would be only an interim phase in the migration to outer space. Before long, mankind would begin mining the asteroids. From asteroid mining, which would be done by free-roving space colonies, there is a natural progression towards using the material of the major planets, such as Jupiter, for the purposes of the human race. O'Neill thus is outlining the first steps towards the creation of a Dyson sphere, with the sun at its centre and the human race lifted to new heights of technology and affluence by its ability to use almost all of the sun's energy for its own purposes.

O'Neill and the scientists who support him think that the space-colony concept is more than just another interesting idea in technology. They think that it is mankind's only hope. They believe that there is no way to provide decent living conditions to the earth's growing human population by using the resources of this planet alone. Even if the human population somehow stops growing, they say, there is no way in which the earth's resources can be stretched so as to lift everyone to the level now enjoyed by inhabitants of the developed nations. By O'Neill's analysis, the earth does not have the minerals needed for universal prosperity. Energy growth cannot continue indefinitely because the waste heat from energy production will cause dangerous climatic changes. And before long, the earth will run out of living space because there is not enough land to provide decent living conditions if the population continues to grow. Even if the deserts bloom and Antarctica is made habitable, O'Neill says, the earth will be miserably crowded in just a few more generations. In theory, the planets could be made habitable. But planetary engineering is so difficult that the only viable alternative is a move into space colonies.

The O'Neill argument bumps straight into a philosophy that foresees an entirely different future for humanity. Space colonies require complex technology and large amounts of money. The future, as seen by O'Neill, is a high-technology future, in which there are no limits to growth.

But a popular philosophy of the 1970s says that small is beautiful, that complex technology is ultimately destructive, that there are limits to growth and that humanity is pressing against those limits now. The small-is-beautiful philosophers agree with O'Neill that the earth cannot support unending growth. Their solution is not to use technology to transcend the earth's limit-

ations. It is to turn our back on complex technology, to limit our desires, and to place our emphasis on living within the earth's means.

O'Neill sees space colonies that offer humanity the ability to extend its control over more and more of nature. The opposing philosophy sees only one space colony – Spaceship Earth – which will have a stable population, a steady-state economy, a decentralised system based on small-scale technology, and a continual reliance on the same limited supply of recycled resources. In this picture of the future, mankind will not invade the cosmos. It will turn its back on space and will tend its terrestrial garden.

The Choice: Space or Stagnation

Prediction is a hazardous affair, but it is possible that humanity is at a turning point. O'Neill certainly believes that there is a clear choice between two roads: one leading into space and technological expansion, the other leading towards what he thinks will be stagnation on earth. If such a choice is being made now, the United States is the place where the question will be decided. Only the United States has the grasp of space technology needed to carry out the colonisation of space. The Soviet space programme is not in the same league. Years after Project Apollo had placed astronauts on the moon several times and Project Skylab had maintained astronauts in orbit for several months, the Soviet Union was still working on rendezvous procedures in earth orbit, with mixed success. Western Europe and Japan are theoretically capable of major space programmes, but that capability remains theoretical. In the foreseeable future, either the United States will move towards space colonisation, or no one will do it.

The prospect here does not seem bright. In his talks with leaders of the Carter administration, O'Neill found that there was no enthusiasm at all for a major expansion of space technology. Shortly after the Carter administration took control of the National Aeronautics and Space Administration, O'Neill had several meetings with the appropriate officials. He came in asking for billions of dollars. He was offered the hope of a few millions, doled out at a rate that would barely keep the space-colony programme alive; instead of hardware, there would be more studies.

The case for a space programme in which tens of billions of dollars would have to be spent is by no means clear-cut. O'Neill

and his supporters say that it will be possible to move directly from studies and some small-scale models to the prolonged support of dozens, then hundreds, of persons in space for longer periods than have ever been attempted. Their cost estimates are based on smooth fulfilment of extremely ambitious schedules. But the history of past efforts to push technology ahead agressively shows that the schedules hardly ever are met and that the costs usually are far greater than had been predicted. Project Apollo was an exception because the moon programme was not really an attempt to break new technological ground, at least to any great extent. O'Neill and his supporters may be correct in all their estimates, but there are grounds for doubt.

There would have been less doubt in the 1950s or 1960s, when money was much freer and doubts about technology were fewer. The O'Neill request for billions of dollars must be seen in the context of the 1970s. The Space Shuttle, on which all of the space-colony plans are based, has just managed to survive several close calls in Congress, and its future is placed in doubt with every new federal budget. As for support for space colonisation from the astronomy community, astronomers generally are much more concerned about a project called the Space Telescope, whose costs are measured in millions, not billions. It is a symptom of the times that the name of the project was changed quietly from Large Space Telescope; the word 'large' was dropped to soothe congressional feelings. Despite some reductions in the scope of the Space Telescope project and despite asiduous lobbying, the orbiting telescope has been postponed several times. Complete cancellation is a constant danger. A scientific community that must work hard to maintain federal funding for what are regarded as essential research efforts is in no position to talk in terms of many billions of dollars for a somewhat risky effort to explore a new space frontier.

The Carter administration is not enamoured of new frontiers; its decision makers appear to have embraced the steady-state philosophy. All the administration's decisions on energy are based on the principle that the future will see a drastic reduction in the energy growth rate. And while the space programme is not fading away, there is a distinct lack of the enthusiasm that John Kennedy and Lyndon Johnson showed for space exploration. To try to get things moving, O'Neill has set up a non-profit Space Studies Institute, which solicits public contributions, and is lobbying Congress for support. But it is hard so see how public contributions and congressional resolutions can be translated into

billions of dollars of federal appropriations when the administration is at best indifferent to a programme and could be actively hostile.

However, things could change. Administrations are not in power forever. In practical terms, not much can be done about space colonies until the Shuttle has flown a decent number of orbital missions, which will not happen until the early 1980s. Public opinion may change markedly over the years; it certainly has changed since the enthusiastic days of the 1960s when Project Apollo was made a national cause. Perhaps the decision to be made about the space colony scheme is a milestone; perhaps it will mark the moment when humanity either goes down the road towards continued technological expansion or takes the route to a self-contained, steady-state existence. But the decision has not yet been made. The choice is still open. It may remain open for many more years.

There is a more pressing decision of immediate importance to SETI – a decision about radio frequencies. The water hole is a popular band for a number of different transmissions. The fact that false alarms have occurred continually even in the limited number of searches that have been made for extraterrestrial intelligence indicates just how popular it is. Unless something is done to limit the use of frequencies in the region of the water hole for everyday civilian and military purposes, a search for intelligent signals may become impossible for earth-based antennas. It may be necessary to put SETI antennas in space to avoid interference, which would mean an enormous increase in cost.

The SETI community is very much aware of the problem. In 1979 a World Administrative Radio Conference will be held to allocate uses for different bands of the radio spectrum. The decisions made at the conference will probably govern the use of the spectrum for the rest of the century. When the convention meets, it will have before it a proposal to study restrictions on the most likely SETI frequencies. At present, the bands from 1400 to 1427 MHz are allocated to radio astronomy use only. The bands from 1427 to 1727 MHz, which lie between the hydrogen and the hydroxyl lines, are also important to SETI. An effort will be made to protect the whole region from 1400 to 1727 MHz for SETI. A resolution has been prepared which does not name the specific frequencies to be protected. But it does say that 'it is believed to be technically possible to receive radio signals from extraterrestrial civilisations', and it asks the conference to determine the preferred frequency bands to be searched

and 'the preferred locations, on earth and in space, for a search system'.

Unlike the space-colony proposal, which could reasonably be described as visionary, the idea of protecting radio frequencies for SETI is determinedly practical. There are only a limited number of usable radio frequencies, and the demands on those frequencies keep growing. The response of the world conference to the request from the SETI community will thus be a valuable indicator of the status of the search for extraterrestrial life today. Is SETI important enough to push aside some powerful financial and national interests? Are commercial interests and military establishments willing to undergo some inconvenience for the sake of an admittedly small chance of making contact with another intelligent civilisation?

The Poetry of SETI

These questions do not reflect the poetry that has been the driving force behind SETI until now. Yes, poetry is the right word. As we read the early writings on extraterrestrial communication – and early means anything that dates back about ten years – there is a clear feeling of wonder that can be described as poetic even though it is clothed in scientific language.

There is speculation that Phobos and Deimos, the two moons of Mars, might be giant artificial satellites (they are, as photographs from the Viking orbiters have shown, pockmarked lumps of rock). There is speculation that the colour changes on Mars visible through terrestrial telescopes might be due to vegetation (they are caused by dust storms). There are Kardashev civilisations and Dyson spheres, asteroids to be mined and comets to be colonised. Now we are down to haggling about money for hardware and the reservation of radio frequencies for a search that could last for decades.

In other words, the search for extraterrestrial intelligence is coming of age. It is moving out of its poetic adolescence at what seems to be an unfortunate time, a time when hard-sceptical questions are the rule. However, those questions would be asked sooner or later even if circumstances were different. If a search for extraterrestrial signals had started in the 1960s, the chances are small that it would have succeeded by now. We might have government officials asking impatiently whether spending would have to go on at the same level, and how long the government might have to spend money on a fruitless effort. We probably

would have the sceptics citing the familiar numbers to support the view that, in the words of D. R. Bates:

> It would be improvident for us to proceed on the assumption that a government of a civilisation belonging to the hypothetical communication network would finance a prolonged beacon effort aimed merely at hastening contact with any relatively recently developed civilisation rather than leaving the initiative to the newcomer as the one having the greater incentive and the easier problem.

There is an answer. 'We believe that signals have been falling on the earth for many millions or billions of years,' said John Billingham. 'If that is the case, why not look for them here. Perhaps if we are sufficiently vigorous about it, we stand a good chance of success.'

So far, the view of Billingham and other believers in the search for extraterrestrial intelligence has prevailed. The two major technological powers on earth, the Soviet Union and the United States, are both committed to projects to listen for signals from another civilisation. The size of the projects and the specific strategies that have been adopted may be disappointing to some people in the SETI community, but the important thing is that the commitment has been made.

The First Chapter in a Long Story

However, this is only the beginning. It is the first chapter in what must inevitably be a long story. Realistically, there is little chance that the limited listening programmes now underway or being planned will succeed in making contact. The odds are great that we will be asked not only to continue these programmes but also to expand them despite years of negative results. Ten and twenty years from now, the same issues will confront the decision makers – except that they will have to make their decisions after many years in which no signals from other civilisations have been detected. It is reasonable to predict that the really difficult decisions about the search for life elsewhere in the galaxy will not be made until the twenty-first century. By then, if present trends hold, we will have had more than two decades of a continuing search for extraterrestrial signals, on a modest but growing scale. Everything that is easy will have been done. Several all-sky scans at relatively low sensitivity will have been completed. Probably someone will have looked at all the nearby

sunlike stars in all the obvious frequencies of the water hole. At that point, a decision will have to be made. The choice will be between giving up, doing more of the same, or paying for a major expansion of listening programmes.

If this is in fact the scenario that is played out, the decision that will be made in the year 2000 will be one of the most significant in human history. It will be significant because the search for extraterrestrial signals is more than just another scientific and technological exercise. It is one of the measures by which we can judge the prospects for the future of mankind.

Scientists cannot measure something without changing what they measure. The chemist who measures the temperature of a solution changes that temperature by inserting the thermometer. In just the same way, the decision about continuing a search for extraterrestrial intelligence affects the odds that the search will succeed. By the principle of mediocrity, we must say that earth is not basically different from other planets where technology may have arisen. Like the earth, those other planets are assumed to have all the problems that afflict our society: pollution, overpopulation, and the rest of the troubles of our time. They must also have come to crossroads where the choice had to be made between embracing technology fully or turning away from technology. They must also have had to decide about continuing an effort to make contact with other intelligent species or abandoning that effort.

The only way we have of even hazarding a guess about the decisions that have been made elsewhere in the galaxy – barring the lucky stroke of making contact quickly, in the next few years – is to observe how those decisions are made on earth. Thus, the measurement influences what is being measured. To give up the search for other civilisations is the most direct way to ensure that we will remain alone. To continue the search is the only way to keep alive hope for making contact with another intelligent species.

In the minds of the people in the SETI community, that is perhaps the most important hope available to the human race. Success in the search for another advanced civilisation offers much more than the hope for a fascinating conversation. It offers the hope that civilisations such as ours can break out of their times of trouble into a long era of stability and prosperity. By the formula invented by Frank Drake, the search for another civilisation can succeed only if there is a large value of L, the lifetime of an advanced civilisation. A decision to continue the search

for such civilisations is thus a vote for a large value of L. At a time when despair is common, it would be a vote of confidence in the future of the human race and in the ability of humanity to master technology.

Whatever the search for intelligence in the universe may find in the future, its most important role today is in keeping that hope alive.

INDEX

Abelson, Philip H., 36
Abt, Helmut, 57
Aerial Phenomena Research Organisation (APRO), 80, 83
Agnew, Spiro, 101–2
Alais meteorite, 38
Algonquin Park Radio Observatory, 117
Alpha Centauri, 89, 90, 92, 93
Ambartsumian, V. A., 68
Ames Research Center (NASA, Calif.), 34, 38, 42, 63, 87, 120, 134, 139, 142, 145, 147–8
Amino acids, 34–7, 38–40, 41, 42
Ammonia, 8, 33, 36, 37, 41, 64, 107
Anaximander, 18, 31
Anders, Edward, 63
Andromeda nebula, 29
Angular momentum (spin), 50–3, 55, 64–5, 69
Apollo (project), x, 101, 135, 139, 141, 143, 159, 162, 163, 164
Appleton, R. L. A., 97–8
Archimedes, 20
Arcturus, 97
Arecibo, Puerto Rico, radio telescope at, 2, 4, 46–7, 118, 120, 124–6, 129, 132, 139, 146–7
Aristarchus of Samos, 19, 20
Aristotle, 19; *Metaphysics* of, 31
Armenia conference (1971), 67–8, 72, 108, 109, 122–3, 125–6
Arnold, Kenneth, 75, 77, 80, 81
Arrhenius, Svante, 32, 39, 58
Asimov, Isaac, 70
Asteroids, 133; mining, 153, 161, 165
Astrometry, 56–7
Atomic bomb, 46, 77, 86

Barghoorn, Elso, 60, 61
Barnard, Edward E., 24, 56
Barnard's star, 56–7, 90, 93, 119
Bates, D. R., 153, 166
Bell, Jocelyn, 114, 121
Bender, Richard A., 1
Bequette, William, 75
Bernal, J. D., 34, 90, 158
'Bernal sphere', 158
Berzelius, Jons Jakob, 38
Bessel, Friedrich Wilhelm, 26
Bierman, Klaus, 12
'Big-bang' *vs.* 'steady-state' theory, 47–9
Billingham, John, 87, 101, 134, 143, 166
Black, David C., 120
Blue Book (UFO project), 77–8
BMEWS, 131, 147
Bok, Bart, 49
Boötis, 97
Bower, Stuart, 120
Bracewell, Ronald, 73–4, 94–7, 98–9, 100, 116, 144, 152
Braude, S. Y., 122, 123
Bridle, Alan H., 117, 118, 119
Bruno, Giordano, 22
Burgess, Eric, 39, 126
Bussard, Robert W., 92–3

Calvin, Melvin, 37
Carbon, 6, 8–9, 11, 13, 50, 124; and origin and evolution of life, 6, 32, 33–4, 35, 37–8, 40, 41, 44, 59–60
Carbonaceous Chondrite meteorites, 38
Carbon dioxide, 33, 44, 60, 151; Venus, 59–60, 61, 68

Carter (Jimmy) administration, 16, 87, 129, 162, 183
Cepheus, and Cepheid variables, 27, 28, 29
CETI, 134, 135; *See also* SETI
Chariots of the Gods?, 83, 84
CIA, 79, 87, 88, 99
Clark, Thomas A., 120
Close Encounters of the Third Kind, 80, 87, 88, 155
Cocconi, Giuseppe, 105–6, 111–12
Comets, 134, 165
Communications, interstellar, 44–57, 67–74, 94–103, 103–21, 121–34; CETI and, 134, 135; costs and financing of, 73–4, 98, 108–9, 111, 119–20, 134, 135, 136, 139–40, 141–7, 149–50; formula for, 67–74, 131; future of, 150–68; listening programmes and (*see* Listening programmes); messages to send, 121–34; SETI and, 134–50 (*see also* SETI); signals and, 103–21 (*see also* specific kinds, e.g., Radio signals); travelling vs., 94–104 *passim;* UFOs and, 75–6, 99
Condon, Edward U., and Condon Report on UFOs, 77–80
Copernicus, Nicolaus, 19, 21, 22, 24
CTA-21, 110
CTA-102, 110
Cuzzi, Jeffrey N., 120
Cyanogen (CN), 37
Cyclops (project), 103–6, 133, 135–40, 142–3, 144, 155–6

Daedalus (project), 90
Däniken, Erich von, 83–5, 155
Darwin, Charles, 23, 32–3, 34
Deimos, 165
Democritus, 27
Deuterium, 90, 91, 102
Dimmick, Robert L., 65
Dixon, Robert S., 118
DNA (deoxyribonucleic acid), 35, 42, 124–5, 128
DNA polymerase, 42
Dole, Stephen, 51–2, 53
Drake, Frank D., ix–x, 67, 112–14, 118, 119, 120, 144, 156; and formula for interstellar communication, 67–75; and interstellar messages, 123, 124–6, 133, 142, 167
Dyson, Freeman J., 89, 102, 109–10; and Dyson sphere, 109–10, 143, 148, 161, 165

Easter Island statues, 84
Edelson, Robert E., 134, 145, 146
Edge of Reality, The, 81
Electromagnetic radiation, 20, 44–7, 130 (*see also* specific kinds, uses); and interstellar communication, 44ff., 110, 111, 130–2, 136 (*see also* Radio signals)
Enzmann, Robert D., 91, 102
Epsilon Boötis, 97
Epsilon Eridani, 56, 112, 114, 116, 119, 136
Eratosthenes, 20
Eukaryotes, 61
Evolution, 31–44; origin of life and intelligence and, 31–44, 61, 69–71
Exobiology, x–xiv, 1–17, 69
Extrasensory perception (ESP), 149, 154–5
Extraterrestrial intelligence (extraterrestrial life), early beliefs and, 18–30; fear of contact and, 133–4; future of, 150–68; interstellar communication and (*see* Communication, interstellar); interstellar travel and, 88–103; possibility of life and, 57–66; search for, ix-xiv, 1–17, 18, 44–57, 58–66, 67–75, 170ff; SETI and, 134–46 (*see also* SETI); technology and, x–xiv, 67–75, 108ff., 154–6, 167; UFOs and, 75–88

Feldman, Paul A., 117, 118, 119
Fermi, Enrico, 74
'Flying iceberg', Enzmann's, 91, 102
Fontenelle, Bernard de, 23
Fort, Charles, 83–4
Fuller, John G., 79
Fusion, 49, 50–1, 91–2, 93

Gairy, Sir Eric, 87
'Galactic community', 100–1
Galaxy, *See* Milky Way galaxy
Galileo Galilei, 21–2, 27, 30
Gas chromatograph mass spectrometer, 8, 9, 11, 12, 14, 15
Gas-exchange experiment, 9–12
Gatewood, George, 55, 56
Gindilis, Lev, 116
Greeks, ancient, 18–19, 20, 27, 30
Green Bank, W.Va., National Radio Astronomy Observatory at, 112–14, 116–17, 120, 123, 132–3
'Greenhouse effect', 66; runaway, 60, 151
Greenstein, Jesse, 144–5
Ground Saucer Watch, Inc., 88
Grudge (UFO project), 77

Haldane, J. B. S., 33, 41
Harrington, Robert S., 54–5
Hartmann, William K., 23, 82
Heliocentric theory, 19, 21, 22, 28–9
Helium, 48, 49, 50, 51, 64, 90
Helmont, Jan Baptista van, 31
Heraclides of Pontus, 19
Herschel, William, 23, 28
Hertz (Hz) radio waves, 45, 105, 132
Hertzsprung, Ejnar, 28–9, 49
Hertzsprung-Russell diagram, 49
Hooker, Joseph Dalton, 33
Horowitz, Norman H., 10, 11, 13–15
Hoyle, (Sir) Fred, 40
Huang, Su-Shu, 53
Hubble, Edwin, 29, 47
Huygens, Christiaan, 22
Hydrogen, 13, 33–4, 35, 36, 37, 40, 41, 44, 48, 49, 50, 51, 60, 61, 64, 90, 93, 124, 126; emission line in space and radio signals, 105, 106–7, 112, 116, 117, 118, 164
Hydrogen bomb, 49, 89, 90, 102
Hydroxyl emission line, radio signals and, 106, 118, 120, 164
Hynek, J. Allen, 80–1, 88
'Hyperspace', 94

Imidazole catalysis, 42
Infra-red radiation, 45, 104, 151 signals, 110
Island One (space colony), 158–62
Island universes, 28, 29, 48

Jansky, Karl, 45–6
Jeans, Sir James, 51, 52
Jet Propulsion Laboratory (JPL, Pasadena, Calif.), 1–17, 59, 99, 134, 142, 145–8
Jupiter, 22, 33, 51, 52, 55, 56, 57; communication with, 126–8, 133–4, 137, 140; Great Red Spot, 64; mining, 161; Pioneer spacecraft explorations, 88, 95, 126–8, possible life on, 64–6, 69, 126–8

Kant, Immanuel, 28
Kardashev, Nikolai S., and types of technological civilisations, 109–10, 115–16, 143, 148, 161, 165
Kepler, Johannes, 21
Klass, Philip J., 82–3, 87
Kuiper, T. B. H., 99–101, 103, 152

Labelled-release experiment, 9, 14
Lagrange points, 141, 160
Lasers, 92, 102, 108, 132
Lawless, James, 34, 42
Lawton, Anthony, 97–8
Leavitt, Henrietta S., 27, 28
Leo 1 (galaxy), 118
Leo 2 (galaxy), 118
Levi, Nissim, 34, 42
Levin, Bernard, 12
Levin, Gilbert, 14
Levine, Norman E., 78
Lewis, John S., 59
LGM-1, 114–15
Light, speed of, 20–1, 45, 89, 92, 93, 94, 99, 101, 110
Light Telescopy, 45, 136
Light waves, 45, 92; for interstellar communication, 108–9, 132
Light-years, 45, 73, 74, 99, 100, 122, 130, 132, 133, 134, 147, 153, 173
Lilly, John, 70
Listening programmes, 94–103, 103–21, 121–34, 134–50 (*see also* Radio signals; specific projects); future of, 154, 166–7; messages, 121–34; travelling vs., 94–103 *passim*
'Little green men', 85, 87, 114, 143
Long-delayed echoes (LDEs), 97–8
Lorenzen, James and Coral, 80, 83
Lovell, Sir Bernard, 111
Low, Robert, 78, 79
Lowell, Percival, 24–5
Lucretius, 20
Lunan, Duncan, 96–7

MacDonald, James, 76
Main-sequence stars, 49–50, 53
Manning, Thurston E., 77–8
Mariner 9, 2–3
Mars, ix, xii, xiii–xiv, 1–17; canals (channels), 3, 24–5; Chryse plain, 2, 10; colour, 6, 165; early beliefs of, 23–6; formation of, 51; life-detection tests, 4, 5–6, 7–17, 62; manned probes, 102; moons of, 165; pictures of, 2–3, 4–6; possible life on, 30, 54, 62–4, 66, 69, 151; rover-penetrator mission, 15–16; temperature, 25; UFOs and, 81; Valles Marineris canyon, 2; water on, 2, 3, 8, 10, 12, 62
Martin, James S., Jr., 4
Maser, 108
Mediocrity principle, 7, 52–3, 54, 167; arguments against, 150–1, 152
Megahertz (MHz), 45, 105, 106, 112, 117, 118, 120, 146, 147, 164
Menzel, Donald H., 81–2
Mercury (planet), 51, 57–8
Messier 33 (galaxy), 118
Messier 49 (galaxy), 118
Meteorites, 8, 13, 37, 37–40, 41, 51
Methane, 33, 36, 42, 61, 64, 65, 72
Methanogens, 61
Metrodorus, 18
Microwave radiation, 132
Milky Way galaxy, 22, 27–30; extraterrestrial life, 44–57, 57–66, 67–75; formation of stars and, 47ff.; and interstellar communication (*see* Communication, interstellar); and interstellar travel, 88–103; and origin of life, 31–8, 47–57; size, 28–30; spin, 55; UFOs and, 75–88
Miller, Stanley, 36
Millikan, Peter M., 25
Molecules: and chemical origin of life, 31–44; interstellar, and radiation, 105, 106; organic, extraterrestrial search for, 7–15, 30, 60–6
Moon, the, x; Apollo project and, x, 101, 135, 139, 141, 143; Cyclops project and (*see* Cyclops); early beliefs of, 19, 20, 22, 23; Hoax of 1835, 23–4; lunar antenna systems and, 139; and lunar tides and evolution, 152; mining, 158, 161; space colonies and, 157–64
Morris, M., 99–101, 103, 152
Morrison, Philip, 105–7, 111, 112, 119, 144, 156
M-13 (galaxy), 124, 126
Murchison meteorite, 38, 39, 40
Murray, Bruce, 59
Murray meteorite, 38, 39, 40
Music, communication and, 129
Mutch, Thomas A., 5

National Academy of Sciences, 76, 79
National Aeronautics and Space Administration (NASA), 15–16, 23, 34, 92, 94, 141ff., 149; Ames Research Center (*see* Ames Research Center); Deep Space Network, 146, 147; and Jupiter-Saturn mission, 128–9; and SETI, 94, 139, 141–3; and space colonies, 157, 158, 162; Space Shuttle, 141, 157–8, 164; and UFOs, 79, 87
National Investigative Committee on Aerial Phenomena (NICAP), 78, 79, 80
Nature, 105, 106, 111, 153
Nebulae, 28, 29, 51, 59, 61
Neptune, 51
Nerva (nuclear rocket), 102
Newton, Isaac, 23
Newton, Sydney, 97
Nitrogen, 37, 40, 50, 124
Nuclear rockets (hydrogen, thermonuclear), 89, 90, 99, 102
Nucleic acids, 34–7, 40–1, 42–3, 124–5
Nucleotides, 35–7, 39, 41–2, 47

Oliver, B. M., 103–4, 136, 144, 155–6
O'Neill, Gerard K., 156–63
'On the Habitability of Mars: An Approach to Planetary Synthesis', 63
Oparin, Alexander Ivanovich, 33–4
Orgel, Leslie, 42
Orgueil meteorite, 38, 39
Owen, Tobias, 63
Oxygen, 12, 13, 14, 25, 33–4, 36, 43–4, 50, 59, 61, 64, 124, 158
Oyama, Vance I., 14, 15
Ozma projects, 112–14, 115, 116, 116–17, 119, 136, 145

Palmer, Patrick, 116–17
Panspermia theory, 32, 39
Parallax, stellar, 26–7
Pasteur, Louis, 32, 35–6
Phobos, 165
Phonograph records, interstellar communication and, 128–9
Phosphorus, 50
Photon rocket, 91–2
Photons, 91–2, 104
Photosynthesis, 43, 64
'Physical Basis of Life, The', 34
Picture messages, communication and, 123–9
Pioneer 10 and 11 spacecraft, 64, 88–9, 98; and plaque message to Jupiter, 126–8
Planets (planetary systems), 44–57; communication between (*see* Communication, interstellar); early beliefs of the universe and, 17–30; formation of, 47ff.; measuring the universe and, 26–30; and motion and speed, 52ff.; origin of name, 17; and search for extraterrestrial

Planets [*contd.*]
intelligence and life, 44–57; (*see also* Extraterrestrial intelligence); telescopy and, 45ff.; travel between, 89–103; UFOs and, 75–88
Plutarch, 20
Pluto (planet), 51, 130
Polymers, prebiological, 40
Ponnamperuma, Cyril, 37, 38, 39–40, 61, 65
Pouchet, Felix, 32
Press, Frank, 87
Prokaryotes, 61
Proteins, and origins of life, 34–9, 41, 42
Protons, 48
Protostars, 49, 51, 52, 59, 64, 69
Pulsars, 115, 121, 127 133
Pyrimidines, 37, 40
Pyrolytic-release experiment, 8–9, 10–12, 14
Pythagoras, 19

Quasars, 116

Radar signals, 4, 46, 130, 131, 132, 137, 147, 153
Radio signals (radio telescopy), interstellar communication and, ix–x, 19–20, 25, 44ff.; 94–103, 103–21, 125, 126, 130–3; Cyclops project and, 103–7, 133, 134–9; false alarms, 114–17, 139; fear of contact and, 133–4; frequencies for, 104–9, 110–12ff.; 164–5; future of, 157–68; kinds of messages to expect, 109–11; messages to send, 121–34; Ozma projects and, 112–14, 115–17, 119, 136, 145; SETI and strategies for, 134–50; (*see also* SETI); 'water hole' frequency for, 107–9, 110–11, 112, 117, 118, 147, 164, 167
Ramjet, interstellar, 93–4
Raper, Odell, 23
Reber, Grote, 45–6
Redi, Francesco, 31
RNA (ribonucleic acid), 35
Romans, ancient, 20, 21
Rosse, Lord, 28
Rowe, Herbert, 129
Ryle, Sir Martin, 121, 133

Sagan, Carl, 6, 41, 62, 65, 66, 69, 73, 86, 102, 109, 118; and interstellar messages, 123, 126, 127, 128, 130, 142, 144
Salpeter, E. E., 65
Saturn, 51, 81, 137; communication with, 128, 137; Pioneer 11 exploration of, 88; possible life on, 65–6; rings of, 22; Titan, 66
Saucer (UFO project), 77
Saunders, David R., 78
Schaeffer, Robert, 82
Schiaparelli, Giovanni, 24, 25
Scientific Study of Unidentified Flying Objects (Condon report), 78–9
Search for Extraterrestrial Intelligence, The (SETI report, 1977), 135–9
Secchi, Father Pietro Angelo, 23–4
Seeger, Charles A., 147–8
SERENDIP programme, 120
SETI (Search for Extraterrestrial Intelligence), x–xiv, 44, 47, 50, 52, 57, 60, 61, 62–4, 134–50; CETI and, 135, 149; costs and financing, 98, 108, 111, 119–20, 134, 135, 136, 139–40, 141–7, 149–50, 153, 155, 165–6; and Cyclops project, 103ff., 133, 134–40, 142–3, 144, 155–6; doubts, hopes, and faith of, 151–6; and exploration of Mars, 1–17, 62, 64; future of, 150–68; and interstellar communication, 67–75, 88–9, 103–21 *passim*, 121–34 *passim*, 134–50; and interstellar travel, 88–103; and lunar antennas and orbiting systems, 139ff.; and NASA, 94, 139, 141ff.; and Ozma projects, 112–14, 115, 116–17, 119, 136, 145; and protection of radio frequencies, 164–5; and size of the universe, 19–20, 30; Soviets and, 148–9; (*see also* Soviet Union); strategies of, 134–50; and UFOs, 85–8, 143–4
Shapley, Harlow, 28–9
Shklovsky, Iosif, 72
Sholomitsky, Gennardy, 116
Sign (UFO project), 77
Signal processor, 145–6
Signals, extraterrestrial, search for, ix–x, xiii, 17, 25, 44ff. (*see also* Communication, interstellar: listening programmes); CETI and, 134–5; future of, 150–68; light (*see* Light waves); and messages to send, 121–34; radio (*see* Radio signals); SETI and, 134–50 (*see also* SETI); and size of the universe, 19–20; UFOs and, 75, 75–88
Silicon, 41, 107, 158
Simpson, George Gaylord, 70, 151
Skylab (project), 162
Solar energy, space colonies and, 157–62
Solar nebula, 51, 59, 61
Solar radiation, 51, 60. *See also* Infra-red radiation; Ultra-violet radiation
Solar System (*see also* Milky Way galaxy; Planets; Stars; Sun, the): interstellar communication and (*see* Communication, interstellar); interstellar travel and, 88–103; measuring the universe and, 26–8; and origin and evolution of life, 31–44 *passim*, 47–57, 152; search for extraterrestrial intelligence and, 44–57, 57–66, 67–74, 152; UFOs and, 75–88
Soviet Union, 58, 72, 74, 114, 115–16, 119, 122, 126, 133, 144, 145, 162; SETI programme of, 148–50, 166
Space ark, 90
Space colonies, ix, xii, 101, 133–4, 156–65
Space probes, 94–7ff., 152; unmanned, 94–7ff.
Space Shuttle, 140–1, 157–8, 163, 164
Space Telescope (project), 163
Spin: *See* Angular momentum
Spiral galaxies, 28, 29, 30
Sproul Observatory, 56
Stars, 26ff. (*see also* Galaxies; Planets; Solar System; specific stars); angular momentum (spin) and, 50–2, 55, 64–5, 69; binary, 52, 54–5; brightness, 26–7, 49–50; and chemical origin of life, 31–44; classification by brightness and temperature, 49–50; communication between (*see* Communication, interstellar); death of, 50; distances, 26–30; formation of, 47ff.; main sequence, 49–50, 53; universe and, 26–30; and the Milky Way, 28–30; motion of, 52, 55–7; number of, 27, 29–30, 67–8; parallax, 26–7; second-generation, 50; travel between, 88–103; UFOs and, 75–88; variable, 27; and zones of life, 53–4
Störmer, Carl, 96
Struve, Otto, 112
Stull, Mark A., 120, 147
Sturrock, Peter A., 75
Sullivan, W. T., 131
Sun, the, 19, 20, 49–50, 55 (*see also* Solar System); as a G star, 49; heliocentric view of the

Sun [*contd.*]
earth and, 19, 21, 22, 29; and laser signals, 108; as a main sequence star, 49–50; size, 20; and ultra-violet light and origin of life, 33–4, 36, 40, 41–4, 65

Tachyons, 94, 110–11
Tarter, Jill C., 120
Tau Ceti, 112, 116, 119, 136, 154
Television, 95–6, 130, 131–2, 153, 173
Tesla, Nikola, 122
Thales (Milesian philosopher), 18
Titan, possible life on, 66
Toth Robert, 149
Townes, Charles, 108
Travel, interstellar, 88–103; communication vs., 88, 94–103 *passim*, 104; UFOs and, 75–88
Trent, Mr and Mrs Paul, 82
Troitsky, Vsevolod, 115
Tyler, Stanley, 60

UFOs (Unidentified Flying Objects), xiii, 30, 74–5, 75–88, 100, 143–4, 154–5
Ultra-violet radiation, 10, 11, 13, 33–4, 36. 40. 41, 43–4, 45, 65
Uranus (planet), 51, 137
Urey, Harold, 36

Vallee, Jacques, 81
Van de Kamp, Peter, 56–7
Van der Pol, Balthasar, 96, 97
Venus, 22, 51, 53, 58–60, 151
UFOs and, 81, 87
Verschuur, Gerritt L., 116, 154
Viking spacecraft, xiii–xiv, 1–17, 62, 143, 165
Voyager spacecraft, 128, 130

Waldheim, Kurt, 129
Water (liquid water): and chemical origin of life, 42, 44; On Mars, 2, 3, 8–10, 11–12, 24, 25. 62; and possible extra-terrestrial life, 58, 59–60, 64, 65, 151
Wickramasinghe, N. C., 40
Woese, Carl R., 61
Wolfe, John, 144
Wright, Thomas, 28

'Zone of life' theory, 53–4, 62–3, 64
Zuckerman, Ben M., 116–17

EXTRATERRESTRIAL ENCOUNTER

EXTRA-TERRESTRIAL ENCOUNTER

A Personal Perspective

Chris Boyce

With a Foreword by

A. E. Roy
Professor of Astronomy
University of Glasgow

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Contents

List of Illustrations 6

A Note on Abbreviations 7

Preface to the Revised Edition 8

Foreword 9
by Professor A. E. Roy

Prologue 13

1 Historical Perspectives 1 22

2 Historical Perspectives 2 34

3 The Dark Pedigree 42

4 Come Up and See Me Sometime 51

5 A Meeting With Tomorrow 60

6 Saucers and Dishes 72

7 Past Contact and the Moving Caravan 86
by Duncan Lunan

8 Meditations of the Heart 99

9 Unbelievably Fatuous Observations 112

10 Them 123

11 High Society 131

Epilogue:
What Do You Say Before You Say Hello? 142

Appendix 1:
A Checklist of ETs in the Cinema 152

Appendix 2:
Relativistic Black Holes 154

Appendix 3:
The Interstellar vN Spaceprobe 163

Appendix 4:
Tomorrow and Tomorrow: A Glance at the Future 166

Notes 170

Bibliography 180

Index 185

List of Illustrations

(*All by Gavin Roberts*)

Members of an archaeological dig unearth alien artefacts

A manned NASA deep-space probe encounters a crippled starship of alien origin

A von Neumann probe in the process of construction in orbit around Callisto

A von Neumann probe in Earth orbit

A von Neumann-type probe departing the Solar System

An asteroid in the process of conversion into a probe factory

A von Neumann probe gathering construction material from the rings of a Saturn-type planet

The head of a von Neumann-type probe using materials gathered from the star system it is leaving

Databank head of a von Neumann-type probe left in orbit around an Earth-like planet

A von Neumann-type probe enters a new solar system

A subprobe detached from a von Neumann-type factory

A 'college' of von Neumann probes exchanging information

A Note on Abbreviations

In the literature concerning extraterrestrials and encounter or communication with them a number of acronyms have been derived which are peculiar to this and closely related fields. A number of these acronyms are used in this book; others have been created specifically for it.

AML	advanced mental lifeform
CETI	communication with extraterrestrial intelligence
ET	extraterrestrial
ETI	extraterrestrial intelligence
ETL	extraterrestrial lifeform
ftl	faster-than-light
LGM	little green men
RBH	relativistic black hole
SETI	search for extraterrestrial intelligence
SF	science fiction
vN	von Neumann probe

Preface to the Revised Edition

When this book appeared in April 1979 there was, to my knowledge, no literature on the principal thesis which I set out in Chapter 8 for contact with another intelligence – that we are likely to encounter one or more extraterrestrial self-reproducing machine/machine-colonies during our exploration of the Solar System. I am pleased to state that this has now been rectified. In the July 1980 edition of the *Journal of the British Interplanetary Society* (Vol. 33, No. 7) there is an excellent paper by Robert A. Freitas, 'A Self-Reproducing Interstellar Probe'. No one who claims to be seriously interested in the Search for Extraterrestrial Intelligence should ignore this striking contribution to the field.

Although no change has been wrought in Chapter 8, Appendix 3 has been entirely replaced by a lengthier, fuller account of my most recent considerations on this subject. There is also some new material in Chapter 9 incorporating a shift of emphasis for that chapter brought about by my recently formulated opinions as to what took place at the famous Socorro UFO sighting.

The only other major change is additional material inserted where it should, I hope, clear up misunderstandings in the text, such as in Appendix 2.

C.B. Glasgow, 1980

Foreword

This is a timely book. The idea that Man may encounter, directly or indirectly, other intelligent species in the Universe in the foreseeable future is one that people today are taking more and more seriously. Among these people are astronomers, biologists, biochemists, philosophers and linguists. Conferences are being held to discuss the problems of looking for evidence of extraterrestrial intelligence and to devise ways of communication with it should it prove to be still around and interested in acquiring pen-pals. Detection programmes have been initiated at a number of radio observatories to look for life; the Viking spacecraft to Mars carried laboratories to do likewise; other space probes such as Voyager carry messages 'to whom it may concern' providing descriptions of mankind's planet and his choicest intellectual and cultural achievements, inviting any intercepting aliens to come visiting. So this book is timely in the sense that it deals with an idea whose time has come.

It is timely also in another sense.

Many people open to the idea that we may not be alone in the Universe tend to think that any future arrival of aliens or communication with them by radio would be basically an exciting, profitable and stimulating encounter with an intelligent species not too drastically different from us in appearance, biochemistry, thought processes, drives and technology. Certainly it would be potentially highly dangerous in its scope for misunderstandings and conflict; certainly the future of the human race would be altered dramatically; but the resulting intercourse in science, technology, culture, philosophy and commerce would ultimately benefit both races, human and alien. This book is a timely argument that such a viewpoint is almost certainly naïve, perilously so, being based on a too-shallow assessment of the situation. The size of the Universe, its make-up and its age compared to Man's duration upon this planet make it almost inevitable that the encounter, when it comes, will produce consequences far beyond our wildest imaginings.

I am a person who has been intrigued by the possibility of extraterrestrial life for more than thirty years, who has read and enjoyed science fiction for many more, who has contemplated with bemusement the growth of the UFO movement since the last war, who remembers with affection and appreciation *Star Trek*, *2001: A Space Odyssey*, *Close Encounters of the Third Kind*, *Quatermass* and a host of other movies stretching back to the days of Flash Gordon and ranging in quality from the sublimely good to the unbelievably bad. I am also an astronomer by profession.

Having read Chris Boyce's book I am happy indeed to have the privilege of contributing this preface to it. The book says a lot of things about the extraterrestrial encounter that seem to me to be well worth saying, things that are relevant, exciting, salutary and thought-provoking. This is a book for anyone like me who has at any time looked up at a sky displaying myriad stars scattered like icy fragments over the dark bowl of night and wondered if life was there and what forms it might take.

Archie E. Roy,
Professor,
Department of Astronomy,
University of Glasgow

Whoever starts out toward the unknown
must consent to venture alone.

ANDRÉ GIDE, *Journals* (May 12th, 1927)

Prologue

Let me tell you how the Universe was discovered.

It happened in the late 1940s. A small boy and his father were returning home by tramcar from a spectacular exhibition of gee-whiz technological goodies held in the city centre. The child's mind was having spasms of delight at memories of jet aircraft, flying rockets and other promises of the brilliant future which lay beyond the waning pall left over Europe by World War II.

The car shambled noisily to a halt. The tweed-coated father stepped down onto the cobbled roadway, turned and swung his boy in a high balletic arc from the platform. The boy howled with glee. He had become one with the aerial pantheon which currently blasted bolts of ecstatic imagery through his never-distant daydreams.

He was a pilot. He was flying the first jet-powered Spitfire. He was anywhere but crossing a rain-splattered Shettleston Road in the East End of Glasgow.

Abruptly the rain stopped.

A divine revelation of colour suddenly flooded into the world around the father and son like blood pumping back into a numb limb. An arm of sunlight, thick and yellow against the overcast sky, had pushed through the clouds and slapped into the roadway.

The boy stopped and gaped. He was unsure of what was happening. He resented the intrusion into his private drama but the spectacle was totally novel and exciting to those young eyes.

The fallen rain was caught as glittering veins laced among the slick cobbles. The boy shook his head, not quite able to place all this into his scheme of things. Then a show of some magnificence, his first rainbow, drew his attention skywards. The luminescent arch grew ever more solid as he watched; then a ghostlier shadow arch began forming outside it.

Now the boy was almost afraid.

He turned to his father, and saw up beyond the man the breach through which the Sun was bursting. It looked like a hole, a hole in the sky.

'Daddy,' he said very seriously, 'What's above the sky?'

'Er, above the sky?' muttered the man. 'Well, there's space.'

'Space? What's space, daddy?'

'Oh, that's what has the Sun, the Moon, and all the worlds and the stars in it. It's very big. It goes on forever.'

'Forever!'

New and vast perspectives began their slide through the young mind. The whole street-scene clothed itself in new meaning, in an image which would dominate that child's imagination thereafter.

The street, dazzling in its countless sparkles of reflected sunlight, became a starfield: infinite, cold and brilliant, stretching away majestic into an inconceivable void. And in there were worlds upon worlds. And upon those worlds were ... what?

Actually there is no way I can really communicate to you what that felt like. It was explosive: the kind of mortal earthquake that sends shockwaves tremoring up and down the rest of your life. The point is that it was personal. It was a private thing, an individual experience.

There is a reason for opening this book in this particular way. What I write in the following pages originates from my individual viewpoint on the Universe. That viewpoint is not a mathematician's, an astronomer's, or a philosopher's: it is a science-fiction writer's, and one SF writer's in particular. It is mine.

Science-fiction writers have a peculiar qualification for writing about extraterrestrials: they probably spend more time on pure speculation about the nature of ETs as beings and civilisations than anyone else in any other occupation.

'Extraterrestrial encounter.' When the phrase is mentioned there is usually a chorus of groans mixed with chuckles. It seems to be a topic which few people take seriously. They seem to regard the subject as belonging to the fantasies of children and intelligent but quixotic adults or practical scientists who really would know better.

Why is this so?

Complex life-associated molecules seem to be found in deep space on an almost daily basis now. Yet still I see that look crossing the faces of people who listen to me as I answer their query, 'Do you really *believe* they're out there?' It's almost as if I am admitting to having seen fairies turning bananas into sports cars or being a founder member of the Flat Earth Society. As I talk to them I see the muscles of their faces undergo a subtle change, a glint of suppressed humour, a flicker of incredulity. There follows what is the nearest thing to telepathy I have known. The thoughts come across as if they were shouted at me: *'My God, they weren't kidding. He really does believe it!'*

There was a time when the conflict of attitudes brought about by innovations could be happily absorbed by society. This time has certainly passed. As Alvin Toffler argues[1] we are moving through a

period when we must now prepare ourselves for the impacts innovation will deal both our society and each of us as individuals within that society.

Programmes concerning the search for and communication with extraterrestrial intelligence have been under way for over twenty years now. Debates concerning the advisability of conducting such programmes have been going on just as long. If this is so, why is the general public so sceptical?

Could it be a matter of exposure? Does the average person equate a contact, an extraterrestrial encounter, with the infamous *War of the Worlds* broadcast put out by Orson Welles? Is any discussion of life on other planets to be considered within the framework of *Star Trek?* Has the broadcasting media beguiled those around us into seeing alien intelligence only in the terms of hoax or fantasy?

If this is so we must begin a crash course of re-education very rapidly.

At the time of writing there is a proposal that the United States' National Aeronautics and Space Administration be funded some twenty-one million dollars for a search programme,[2] and the Soviets plan to place a satellite in orbit to further their studies in this field.[3]

If our technology continues to become ever more refined and we maintain a growing interest in searching for other intelligences the chances of us making an encounter over, say, the next century and a half must become quite impressive, if there is anyone there.

My assumption in writing this book, my personal belief, is that someone is there, or was or will be, and that at some point we will become aware of the fact as a piece of hard irrefutable data. If I can make a private moral bet with myself I will say that this will take place within the next fifty years. When it occurs, the cultural impact may well have a potential dwarfing that of any remotely similar happening in human history. That is why we must prepare for it now.

How do we prepare? We are dealing with a completely unknown factor, the extraterrestrial. How can we possibly come to terms with an eventuality the very nature of which is completely outwith the realms of mankind's knowledge? Obviously there is no way we shall be able to write a manual which will cover everything we should do in every conceivable situation. The permutations of imaginable encounters are probably limitless and, when we do effect a genuine encounter, there is one thing that is certain about it: it will contain elements which we never did and possibly never could imagine.

Before we abandon the unknowable alien entirely we should investigate any method of probing its nature. At present our only tool is speculation. If we bear in mind that any speculative being which we raise in our imaginations will at best only partially resemble the ET, then each of us may speculate. Each of us *should* speculate. Once the sceptics themselves begin to speculate we are in a healthier environment. Then, once everyone realises that even the richest most probable imaginings are little better than smudged sketches of what the reality is going to be, we begin to adopt a social posture which is ready to accept an encounter.

Let me go into this in some detail.

It is important that as many people as possible begin to consider what the consequences of contact may be for them, individually and as members of society. Certainly the imaginative processes involved will entail masses of wild analogising. As the nature of the ET is unknown the only solid boundary to the imagination is the very fact that the ET is a complete mystery to at least most of the human race.

Even so, we must approach it, and to do so we must be more fanciful than we would like ourselves to be in our modes of thought. We must create the alien's image for ourselves because we cannot see it. That being the case I want to take a look at mental creativity for a few moments.

I am convinced that we create by finding new and striking analogies between elements in our known world which have never been related to one another before. When we are faced with a problem we extract those elements from it which we can relate to and attempt new relationships with the problem until we understand it; solve it; grasp how it interacts with the rest of our scheme of things.

Let us take the fictitious case of Dr Duck and Dr Goose. Duck is puzzled as to what makes the Sun shine. One chilly night he is ruminating on this while sipping his hot tea and gazing into the fire. Suddenly a eureka bulb lights up in his mind. *Of course! The Sun is made of blazing coal.* He rushes into his laboratory and starts work on his hypothesis. Knowing the size of the Earth, that of the Sun and the distance between them he begins work. Sadly his results show that his hypothesis is utterly mistaken.

Seventy years later Dr Duck's grandson Dr Goose has a similar brilliant revelation while he is working on nuclear physics. He rushes into his lab when the idea occurs that the Sun may be powered by the fusion 'burning' of hydrogen into helium. His theory stands up. Where Duck collected only obscure references to

himself in technical journals, Goose collects his Nobel prize.[4] Both men were trying to explain the unknown in terms of the known.

Both men operated by use of analogy.

Both recognised aspects of one thing which they thought could be applied to another. They saw parallels.

We tend to operate this way when faced with a mystery. We pour analogies like liquid wax over the object of our inquiry and then build models from the mould we have made. If the model is unsatisfactory we use new wax, new analogies.

With regard to the ET it is the exercise itself which is important. The continual construction of models and their disassembling and restructuring in novel ways with original elements – this is the essential. The imagined ETs are secondary. Each of them must be profoundly flawed.

The reason for this is the difference in the position of the ET problem and those who wish to tackle it. Arthur Koestler writes:

> To put it a different way: solving a problem means bridging a gap; and for routine problems there usually exist matrices – various types of prefabricated bridges – which will do the job; though it may require a certain amount of sweat to adjust them to the terrain.[5]

The ET problem is complicated by the complete lack of adequate 'bridges' and any recognisable 'terrain'.

What terrain does exist? Let us regard the whole corpus of human experience as the Continent of Certainty. Then we guess that somewhere out there in the infinite Ocean of Mystery exists the Island of Probability: we do not know anything about it except that we believe that it is there, somewhere. Our task is to provide a variety of specifications for the bridge to that island.

We can attempt this only by employing abstractions. These are quite literally not capable of being perceived by the senses. In this sense every ET is an abstraction to us. We should bear this in mind because the abstract has a particular quality of which we must remain conscious whenever we deal with the aliens we conjure from our imaginings: the abstract never includes all that can be said about the real; it represents an element or group of elements which have been selected from the real and held independently to represent an aspect of the real. This gives us an indicator.

Any ET we imagine is by the definition of abstraction incomplete, no matter how detailed and convincing we make it appear; consequently no amount of inference from what surrounds us on the Continent of Certainty can tell us everything about the Island of

Probability. It may tell us something. The problem is that we cannot know which speculated particulars of the Island of Probability are accurate or how important they are in relation to one another or to the Island's unknown elements.

This is where we come to realise that our bridge-designing, our model-making, can be useful only as an exercise. A model relates to a system the way that a map relates to a geographical area. The only real systems of which we are aware lie within the Continent and thus we are building there mock Islands and mock bridges. The more we do this the better we become at bridge design. The more varied and difficult the mock Island's terrain the higher grow the chances that we will build the correct type of bridge when the true Island is sighted.

The great problem is dogmatism.

A dogma of ET types evolved from theoretical model-making could be disastrous in the event of a real encounter. Unfortunately, we humans are prone to dogmatism, and it is so easy to confuse the imagined with the real. Jean-Paul Sartre says:

> The two worlds, real and imaginary, are composed of the same objects: only the grouping and interpretation of these objects varies. What defines the imaginary world and also the world of the real is an attitude of consciousness.[6]

The attitude is always to be regarded as suspect where models of the ET are discussed. We must never, for example, assume that the apparent comprehensiveness and/or complexity of a model enhances the prospect of its validity. It should be carefully instilled in all who speculate upon the nature and results of encounter situations that we are performing two limited actions when we make our analogies. First of all we are working with the shakiest form of deductive reasoning, infamous for its capacity to yield invalid conclusions from solid premises. We must also consider the factors which we appoint consciously or unconsciously as those from which we will analogise: we must consider them sceptically because, as I have said, they all originate from the Continent of Certainty.

So where do we SF writers fit in?

We deal out images like cards and each is a story, a dynamic thing. Sartre defines the image as 'an act that is directed towards an absent or non-existent object as if it were an actual body'.[7] This brings me closer to how I see good SF handling the problem.

We want to make the act realistic, exciting and a challenge to the imagination of both the SF reader and the average non-

believer in the street. We want to make it seem possible. T. S. Eliot wrote: -

Between the idea
And the reality
Between the motion
And the act
Falls the Shadow[8]

At our best we are trying to penetrate that Shadow.

There is already a vast body of speculative fiction dealing with encounters. Literally hundreds, if not thousands, of established, budding and nascent SF writers deal with 'aliens' daily. They have done so, if not in such numbers, for at least a century now, certainly years before H. G. Wells' first Martian missile crashed down upon Horsell Common in 1897.

How much credence should we give the idea that SF writers genuinely attempt to simulate non-human intelligence and civilisation? Naturally, being 'one of the gang' I am biassed here to some modest degree. Certainly most SF writers are in the entertainment business and they are in that business to make money which supports wives, children and roofs over the various heads. They are also, for the most part, writing for what they see as a discriminating readership which knows that there are no two-hundred-metre-high methane-breathing swamp giants on Venus and that you cannot travel faster than light in the Einsteinian Universe without a handy 'spacewarp' or 'hyperdrive'.

The trouble with encounter scenarios in SF is that the worst treatments are given the widest circulation.

By and large, the examples which appear on screen are simply trash. In the case of television the scriptwriters concerned are often the same team who work on the opera circuit; i.e., soap, cop and sixgun operas. These writers are highly skilled professional people who can rattle out, alter, scrap and rewrite a smooth custom-built screenplay, precisely to order, and have it on the producer's lap by or before deadline. To the TV companies they are invaluable. For our purposes they are truly worse than useless because they tend to perpetuate the less savoury aspects found in the worst, and some of the best, of the old 'pulp' SF stories.

There is a stong accent on violent conflict and human chauvinism is always rampant. Carl Sagan, the space scientist, uses the concept of chauvinism in the sense of 'the assumption that life elsewhere has to be, in some major sense, like life here.'[9] In the great garbage-can

where most mass media SF belongs, human chauvinism also means human superiority. The aliens may be more intelligent than we are but, if so, they lack our emotional capacities and our frequently startling powers of intuition. Naturally their centuries-long technological lead is no match for such capabilities. The result of this is that the alien is defeated and destroyed. Despite the chauvinism there are few instances in SF of books or films ending with a negotiated peace treaty. Human reality seldom intrudes into the dreamworld of human chauvinism.

In Appendix 1 I have compiled a selected checklist of movies which deal primarily with relations between Us and Them. A quick glance down it will show that most film-makers involved regard violence, often straightforward warfare, as being the kind of relationship between us and the ET which the public finds most acceptable. Where outright guns, bombs and death rays play a lesser or even non-existent role there is generally some element of menace. The beautiful extraterrestrial may turn out to be a vampire, for example.[10] Alternatively, the invaders may be pyschic parasites which take over or absorb human personalities as was the case in, respectively, *Quatermass II* and *Invasion of the Body Snatchers*.[11]

In the latter film the final scene is open-ended: the invaders just may manage to take over planet Earth. This is exceptional. Generally the intruders are well and truly hammered in the last reel and the human race survives having learned to 'Keep watching the skies'.[10]

Is the ET simply a handy vehicle for quasi-gothic melodrama and pseudo-technological pyrotechnics? Evidently there are those who think so. The problem is, why do they think so? Is it something about the way we react to the very concept of a non-human intelligence at least as advanced and complex as our own?

Do I hear someone shouting 'Fear of the unknown'?

Possibly it is that in part. There is however the lurking suspicion that the ET may do unto us as we have done unto others. In history, where one nation has conquered another there has been extensive and frequently cruel exploitation of the conquered. Colonialism and its present-day economic equivalent, neocolonialism, are fairly well known to most individuals in the West. There is either an abhorrence of the imperialistic overtones associated with them or a variant of the attitude, 'It's good for them because we're civilizing them after all.' In either case the prospect of our encountering superior beings does not bode well.

Wells illustrated this beautifully in *War of the Worlds*. The invading Martians care nothing for what we humans hold dear and

are intent only on subduing us. Their technology is imcomparably superior to mankind's, their intellects 'vast and cool and unsympathetic'. One of the finest ingredients of the work is its illustration of the fear engendered by this prospect; evidently it shook the author himself to some extent. Mere human invention was useless in dealing with the invaders so, incredibly, the atheistic author had them destoyed by 'putrefactive and disease bacteria ... the humblest things that God, in His wisdom, has put upon the earth'.

Certainly, if the social behaviour of the ET is rather close to our own, this possibility should not be ignored. SF abounds with variations of human social conditions attributed to the alien. As in *War of the Worlds* there are carefully considered non-human intellects with strange social organisations. In *The Alien Way* Gordon R. Dickson creates another highly aggressive set of beings, the Ruml, who have a complex society based on kinship and the establishing of powerful bloodlines. In *A Case of Conscience* James Blish's aliens are a threat to Man's image of the Universe, particularly his own place in the scheme of things, as seen from the viewpoint of a Jesuit priest.

There is just no adequate way of referring to the nature of the ET without using SF.

I am not saying that if you want to seriously consider the implications of contact you should write an SF novel. The real extraterrestrials will not be the same as any imagining contained within the hundreds of thousands of stories written about them. There is, from our limited experience, a fair chance that somewhere in that body of literature are a number of pieces which will have a bearing on the problem when it really arises. The problem is so open-ended that it requires an extensive library of speculated possibilities to be tackled at all. This is what Sf provides.

Given that, where do we start our study of the encounter? We begin with the other side of the contact 'equation', the terrestrial element, the human animal itself.

1 – Historical Perspectives 1

Let us look at Man. He has a wide experience of intercultural contacts. For over five thousand years he has been building cities and creating nation states each with its own distinctive characteristics. The history of cultural encounter begins with history itself, but it should be remembered that there is also an impressive prehistory.

The nomadic and semi-nomadic tribespeople of the Paleolithic period must have met with other goups in their travels. It is even possible that *Homo erectus* of one million years ago had rudimentary tribal cultures which interacted to some degree.[1] To me it appears very difficult for a culture to emerge, thrive and ultimately disintegrate without having some interchange with beliefs and *mores* of other cultures, or civilisations. Sadly, all we can say with much certainty about prehistoric cultural interchange is that it must have taken place. When we move into the realms of our historical past we are on much firmer ground.

There is an argument against the use of historical illustration when considering contact with ETI (extraterrestrial intelligence). It is a valid argument to some extent: we cannot use examples taken from human history since the non-human behaviour of the extraterrestrial nullifies their relevance. This is certainly true when the contact 'equation' is considered as a whole. History is a useful source only when we are examining the human factor.

We know nothing about the psychology of the ETIs. There are reasons, which I will come to in due course, to suspect them of having mutually exotic psychologies. However, to deal with the contact analogies forwarded by both critics and supporters of CETI (communication with extraterrestrial intelligence) it is necessary to assume on their part some quasi-human behaviour. Where possible, however, I will stick as closely as possible to the human side of the equation. In *A Study of History*, Arnold Toynbee[2] points out that there are two extremes of reaction to cultural impact. He called these 'Herodianism' and 'Zealotism' after the Judaic reactions to Rome. In the former, a chameleon-like attitude is adopted in an attempt to become as like the assaulting culture as possible; the latter reaction is to become ultraconservative and eschew everything foreign as a contagion. We should expect both types of reaction to some extent in the ETI en-

counter. The extent will vary depending upon the nature of the encounter.

We can already recognise the Herodian and Zealot-like psychologies amongst those who make public statements about intelligent life in the Universe. There are those who find the prospects of contact with an alien intelligence highly exciting and promote the idea that we should be actively attempting to discover ETIs. On the other hand, there are those who discourage the idea of drawing attention to ourselves, who believe that we are not yet, and may never be, ready to deal with the problems which CETI might bring.

Perhaps the main fear which lingers in the mind of the individual in Western civilisation today is inherent in the process of Westernisation itself. Western influence spread from Europe in the fifteenth century to touch all parts of the globe in varying degrees within five hundred years. The expansion has been highly aggressive, if not always violent. In its development the Western way of life has changed in numerous ways. But one element which has remained is the aggressive nature.

What if we encounter an ET culture as aggressive and vigorous as our own? Will our fate be similar to that of the less aggressive societies which have been subjected to the fatal impact of exposure to the West? An analogy could be found in what happened to the American Indians when the European invasions swept across their lands. The Europeans and those of European descent often treated the native population as little more than dangerous local fauna.

The pre-Columbian populations had created their own complex cultures. In Central and South America extensive imperial societies had arisen by the time the Spaniards arrived, notably the Aztec, Maya and Inca. Amerindian civilisations and cultures are now matters mainly for the archaeologist and anthropologist; the influence of European thought and technology destroyed them at the level of authoritative dominion.

The Fatal Impact is the title of a book by Alan Moorehead about the effect of European presences, mainly British, in the South Pacific between 1767 and 1840. The West is shown as destructive, domineering and insular in its attitudes towards the local population. The results of Westernisation among the South Pacific's aboriginal people are, if not worse, then scarcely better than the lot of the American Indian.

The question which arises here is whether or not these are fair analogies to draw with ETI encounter situations. Few scientists believe that such an encounter will take the form of a spaceship from another planet suddenly materialising above the Earth and

landing on the White House Lawn, Red Square, or anywhere else for that matter. It is generally thought that we are more likely to receive a very old, perhaps centuries or millennia old, message from a distant civilisation with whom it would be impossible to have any other relationship than polite conversation punctuated by pauses decades or perhaps even centuries long.

Currently, faster-than-light (ftl) space travel is regarded as being, if not actually impossible, definitely unfashionable. This slightly less than respectable concept is implicit in the idea of a galactic or at least interstellar civilisation as we understand the term 'civilisation'. For a society to function as an administrative whole it is necessary that there be some fairly rapid transfer of information between the outlying regions and the administrative centre or capital. By 'fairly rapid' I mean to say that instructions on, say, general policies to be adopted by regional governments might arrive from the capital once every five or six years at the outside. The problem, of course, is that, if the instruction or flow of feedback take an excessive length of time, then the outer regions will become progressively different from the society of the capital because the seat of administration will be unable to react fast enough to regional changes to stop, divert or influence them effectively. By the same token, the 'regions' would differ internally to a lesser extent. A galactic empire governed by the laws of physics as we understand them today would be a temporary affair indeed. Remember, a galaxy is a very large place. A beam of light takes roughly one hundred millennia to cross our own, yet it takes less than one tweny-third of a second to travel thirteen thousand kilometres, which is the polar diameter of Earth. And that thirteen thousand kilometres in human terms would involve the ridiculous image of well over seven million adult males lying in a straight line head-to-toe.

Most people regard civilisations as fairly cohesive with regard to internal communications; consequently, any interstellar civilisation would have to find some method of by-passing the restrictions of physics as they are currently understood.

Let us then assume that we do physically encounter a vast aggressive interstellar society which has managed to achieve ftl travel. We shall assume that they have been attracted by the television and radio riot which we have been showering into space for decades. If they have been anywhere in our vicinity since mid-century, there is a fair chance that they have heard us. By now we have surrounded ourselves with an incredibly immense sphere of commercial television signals. The TV sphere's radius is currently

about thirty light years and growing at the speed of light.

It is difficult to think about distances in terms of light years, so think of it in terms of the volume of our world. Earth's volume is better than eight hundred million cubic kilometres. The TV sphere expanding out from us among the stars is some ten thousand billion billion billion times larger than that at present. By the turn of the century it will be almost three times as large again.

So Earth glows like a radio beacon for the ETIs inside our TV sphere. What happens when their spacecraft appear in the skies above us?

We can be fairly certain that, if they are as aggressive as Western society has been for the past five hundred years, we could find ourselves in trouble, particularly if they regard us as local fauna to be classed along with the other apes. It is generally assumed that this is and always was the normal attitude adopted by the European towards the aboriginal inhabitants of lands he moved into. But is this a distortion of what happened?

Most human beings seem to treat other human beings who are markedly different from themselves racially and culturally with mixed degrees of curiosity and caution, if only at first. This is a perfectly understandable response. Caution is always a factor which emerges when an individual or group is dealing with a new situation.

Regarding the strange person or group with hostility is liable to arise where they compete for limited resources, or theaten the social aspirations of the observing individual or group. The lack of compassion between conqueror and conquered has never been exclusive to intercultural or interracial conflict. Any brief glance at the history of Europe alone is sufficient to demonstrate this. Western society is aggressive. It is also expansionist and economically growth-oriented. The difference between it and aboriginal society is more a matter of kind than of degree. The aboriginal is tradition-oriented to a great degree whereas Western societies are geared more to rapid change. The aboriginal society is thus a poor analogy to use when speculating on a cultural impact requiring change on our part in order to survive culturally. In consequence it is difficult to parallel an ETI contact along North Amerindian or South Pacific lines.[3]

The Inca, Aztec and Maya civilisations, on the other hand, were far from aboriginal. They were socially complex, highly enough organised to have dealt with the Spanish invasions quite decisively before the invaders obtained a secure footing in Central and Southern America. So what happened here?

Unfortunately, it needed more than organisation and technology to combat sixteenth-century Spain.[4] There was a cultural difference which worked heavily in favour of the Spaniard. Spain was expanding at a time when European civilisation was exceptionally vigorous. Dreams of wealth and conquest obsessed the adventurers sailing westward, who had more often than not sunk a great deal of personal wealth – as well as that of their sponsors – into the expedition. Consequently, it was critical to return across the Atlantic with, at the very least, promise of great fortune.

The Aztec did not realise that he was dealing with people who had the mentality of gamblers and the cravings of the power-hungry. It was the audacity, ruthlessness and technological sophistication of the Spaniard which proved overwhelming. The Inca, Aztec and Maya cultures were destroyed because the invader wished them destroyed. The natives in the upper levels of their social hierarchies adopted a Herodian attitude and moulded their lifestyles into an acceptable quasi-Spanish format. State religions were officially replaced with Christianity and the peasantry were enslaved. Of course, a great deal of the Herodianism was merely the application of what was hoped would be an acceptable veneer. Many of the old beliefs and customs were still in existence but somewhat disguised. In fact, some village communities outwith the invaders' ambience continued much as they had before the Spaniards arrived.

Spain wanted empire and gold. The indigenous political structures of their new lands posed a threat to stability of rule, and consequently had to be demolished and replaced with true colonialism.

If we were to run up against an equally ruthless, cruel and exploitive space-going community which was at least as advanced compared to us as were the Spaniards to the American Indian civilisations, then we too would be in trouble. There are, however, some features which make this appear a less likely possibility than the ETI being comparatively non-aggressive. The first of these is the very nature of contact, of how we currently envisage an encounter.

It is because we are expanding our presence actively out into the Galaxy that ETI encounter is becoming increasingly possible. It would seem from examples of historical encounters that it is the expanding society which initiates these contacts. If this is so, then we can expect the encounter to be brought about by our own efforts.

We may meet another society, but can we expect them to be as expansionist as we presently are, from our historical experience?

The possiblity of an interstellar invasion fleet, but-eyed Cortés in command, arriving in close orbit about the Earth is scarcely more likely today than at any point in our past.[5] The chance of anyone invading a country just at the point when it was undergoing an explosive aggressive situation itself would seem a fairly slim one. If, for example, Pizarro had landed in Peru about a century earlier, when the Inca empire was expanding rapidly, he would have met with a vigorous, conquest-oriented enemy and his victory would probably not have come about so easily, if at all.

If we do make an encounter it means that, evidently, there are other intelligences out there, and this entails the probability that they are already experienced in contact. So much depends upon the rate at which 'civilisations' emerge in the Galaxy and how long they continue to exist. The chances would seem to be against these factors dictating the mutual encounter of two civilisations in exactly the same condition of sociocultural and technological development.

As we are at the very start of our contact programme we are thus likely to encounter an older Intelligence wise to the fact that emergent lifeforms among the stars can be aggressive. Doubtless it will permit us to make contact only when it feels we have matured sufficiently.

What if this is not the case? The aggressive processes of Westernisation have been continuing for some five hundred years and show no signs of abatement. Might we not have to face an ETI which has been involved in aggressive expansion for thousands of years? This would be the ludricrous equivalent of Spain's Conquistadores discovering not the Inca and Aztec gold but the much more alluring glitter of twentieth-century North America.

Above all it is this kind of cross-temporal contact which has relevance to our situation. We must realise that coming into contact with a society at once as vigorous and and almost certainly more complex than our own has as much relevance to time as it has to space. As we can talk with any degree of confidence only about human societies, we must think of ETI encounter in the light of our present civilisation communicating with representatives of a descendant civilisation some centuries hence.

It would be more appropriate, accordingly, for us to investigate contact between our society and others where the impact of the West was felt as near to the present as possible and where the societies concerned were comparable in cultural stability, aggression and social complexity. Possibly the best model would then be that of the Japanese over the past one hundred and twenty-five

years. From being a decidedly insular feudal society in the middle of the nineteenth century, Japan has transformed herself dramatically into a potent global force economically and politically.[6]

The attitude of the United States in forcing open the channels of communication between Japan and the rest of the world is very important here. The intentions of the United States were not colonial, at least in the traditional sense, although perhaps neo-colonial in the modern sense. They arrived in 1853 with a moderate show of military might; later they returned to Japan with more ships, carrying a greater complement of soldiery. They were, however, not interested in military conquest.

Had the United States chosen to manufacture an 'incident' it would have been fairly simple, the attitudes of the Japanese being almost pathologically xenophobic. A fair-sized military expedition, particularly one with good logistic back-up, would possibly have crushed the native armies of the islands as they then stood. Considering the renowned spirit and resourcefulness of the Japanese warrior, this statement may seem rather extreme, but there is evidence for it. The evidence is relevant to this investigation of cultural contact.

The traditional warriors of Japan were a hereditary class, the Samurai. These men were extensively trained in the martial arts and lived by a strict behavioural code which governed even the minutiae of their everyday lives. It was only to be expected that when, due to the processes of Westernisation, it was decided to disband the Samurai and replace them with an army drawn up along regular European lines, they would object.

The predictable outcome was a showdown between the newly trained force of conscripts and the Samurai. The conscripts won decisively. A Western-style Japanese army defeated the Samurai just as convincingly as the Conquistadores defeated the American Indians. It is the presence of a Western format which both instances have in common.

What factors contributed to Japan's rapid assimilation of Western cultural elements? To understand this we must look at the country existing, not in isolation, but as part of the Far East which from the intrusion of the Dutch traders in the fifteenth century was faced with the 'Western Problem'. The Japanese initially opted for a 'Zealotist' solution by cutting off all but token contact with Europe in 1639. This was done because they did not like what they saw of the exploitive actions of the Europeans. They also had serious doubts concerning the religious, moral and hygenic aspects of the intruder.

This placed them in a situation where they were aware of the West but deliberately ignored it. It was an outside, an 'alien' presence, which stayed outwith the orbit of their own affairs. Although we cannot be certain that a contactable ETI exists, the nearest situation analogous to our belief that it does exist, our blind awareness, is probably the two centuries of Japanese isolation. The main differences are that our isolation is not self-imposed, and that the Japanese awareness was not blind.

Although cut off from the West, news of what was happening in other parts of Asia was obtained quite readily. So, when Perry arrived with a demonstration of nineteenth-century US naval power, the Japanese were quick to realise the consequences of ignoring it. They knew of the British presence in India and the Dutch and French intrusions around the East Indies and Indo-China. They were well aware that they would have to react decisively. Ironically, the Spanish conquest of the Philippines in the late 1560s and the Dutch conquest of Formosa in 1624 had been contributory factors to the isolation policy. It was fairly evident that, if they did not rapidly catch up with the West in military terms at least, then they too were likely to become a subject nation at some future point.

However, it would be wrong to say that Japan was caught totally unprepared. In the earlier part of the nineteenth century there had been some very discreet studies of Western knowledge, particularly in the sciences, by a number of scholars who eagerly, and secretively, learned what they could from the very few Dutch traders who were still permitted to enter the port of Nagasaki. Study of Christianity was banned, but not the pursuits of Western medicine, astronomy, chemistry and military science. These could be followed, but only privately.

There is an analogy here with CETI, which is the scarcity of information we have available, the smallness of the band who are studying it, and its difficulties in being given official credibility by the scientific establishment. The amount of information about chemical evolution and the presence of complex molecules in interstellar space has grown rapidly over the past ten years. It has even been postulated that the thunderstorm-ridden lower atmosphere of Jupiter should be thick with the chemical bases for life. We still know very little, but our information is growing, and with it our perspective on Man's place in the Universe is changing.

Likewise, the Japanese were not wholly isolated from the West during the period of seclusion. They had a number of indicators that, although their own technology had remained static, the

West's had not. As the eighteenth century drew to a close, more and more of the unwelcome Western ships tried to gain entry to Japanese ports. 1808 saw a British vessel enter Nagasaki on the excuse of pursuing a Dutch fleet. The captain demanded supplies of the populace, threatening to sink every ship in the bay unless his request was met with promptly. Even Perry's traumatic appearance in 1853 was presaged some five years earlier by another American, Commodore Biddle, in an attempt to establish trade relations without resorting to a show of weaponry.

Between 1853 and the turn of the century was the period when Japan reacted to the West. The reaction was as extreme as that of the 1638 isolation edict. By the end of the first decade of the twentieth century, Japan had an army based on the German model, a navy modelled on the British, a French-type legal code, a centralised bureaucracy, a bi-cameral system of government, a Prime Minister and, that ultimate stamp of civilisation, an Emperor who was a knight of the Order of the Garter.

But ending the seven-hundred-year rule of the military feudatories proved to be a painful and difficult process. Again there are indications of parallels which may well prove relevant in an ETI contact, particularly so in the event of the ETI having very little or no knowledge of human affairs.

By 1858 the Russians, Dutch, French and British had followed the American lead of obtaining treaties with Japan. They regarded these treaties as being masterworks of diplomatic ingenuity. True, they had tricked the Japanese into concessions which were unusual, for example extra-territorial rights over their own nationals in Japan, which effectively placed the foreigner above state law. Furthermore, the Japanese could not decide what tariffs they would levy without consulting the trading treaty partner affected. The quasi-colonists felt pleased with themselves because they had ensured that the Shogun, the country's military overlord, signed the treaties and not the anti-Western Emperor. They believed that the Emperor's real political power was virtually non-existent. In this they were correct. What they did not realise was that by this time the political power of the Shogun was not much more impressive than that of his Imperial master.

Real power was held by a number of noble families. If *they* so decided the clever-clever treaties could be declared invalid, as they did not have the stamp of Imperial approval. Unknowingly, the Western powers had outsmarted themselves. The Emperor wanted the 'barbarians' expelled as soon as possible. Internal conflict was inevitable.

Again the 'Zealot' and 'Herodian' elements are apparent. In an ETI contact we must expect them to emerge just as naturally as they always have in human history. May we be as fortunate in the resulting struggle's outcome as was Japan.

Although the often bloody internal dissent was to continue for a further eight or nine years, by 1868 Japan had settled its power struggle in favour of the 'Herodian' group. This consisted of the younger members of the dominant clans and their Emperor, a fifteen-year-old-boy. The group had all experienced the post-1853 years of crisis as their formative years. They saw the shogunate established centuries earlier by Tokugawa Iyeyasu as a decayed structure, collapsing on those within it. Contact, the ultimately irresistible contact with the West, was the final blow which shattered it.

The group saw the hierarchical social organisation disintegrate as a means of administration. They also saw something else which made them decide that the rapid adoption of at least Western military standards was essential. What they saw was Russia menacing Japan with territorial designs upon the islands.

An ETI encounter demonstrating that the alien civilisation's technology is superior to our own might produce a similar reaction in us. We may not even understand the language of the beings, or what their technology is really all about: the very fact that it gives them capabilities which we do not have would tend to create anxieties about the security of the human race. Just as the Samurai of the various clans disappeared with the formation of a national army, so might our various national armies disappear with a demand for a Pan-Human Defence force.

There is of course a great problem here. Who administers the power? Who is in control of such a security group? Japan had to create a new social and political structure. We may well be forced to do the same. Japan was fortunate enough to choose among the systems then being used by the more technologically advanced nations. However, in an ETI encounter, where the ETI is naturally different from ourselves in basic psychology and social relationships, it is unlikely that we will be able to do the same. The chances of another creature or creatures evolved along the same lines as the human race meeting up with us must be inconceivably small. Consequently we may have to pull ourselves up to the required level of sociopolitical sophistication by our own proverbial bootstraps.

The chances of our managing this are not as remote as they seem. If the nature of the ETI is quite fundamentally different from our own, and we are in a position to see this for ourselves, the various

conflicting powers on Earth would have in common a wish to resist any social influence from the alien culture. In other words, a 'Zealotist' attitude would likely develop strongly with regard to what we saw as weird behaviour in the alien. At the same time we would try to emulate their techological achievements and adapt to our requirements the social organisation they used in attaining these. This would entail some degree of 'Herodianism' a well.

Bearing the Japanese analogy in mind, it would seem fitting that, in the aftermath of ETI encounter, we employ as many responsible change-oriented individuals as possible in the process of adjusting to the new pressures. At time goes on it may prove even more fruitful to employ in positions of responsibility those people whose formative years were within the adjustment period, as the Japanese noble families did in 1868.

It would be naïve to imagine that the current world political structure at and immediately after the moment of contact will bow graciously to all this and adapt accordingly. So what is achievable? It seems that unless bloody conflict is to result we should use the political machinery available in each country today.

In countries with a multi-party political system it is not uncommon to discover political movements which cut across party boundaries. These often marshal support by forming groups composed of members of the various parties working in concert for their agreed goal. Hopefully, several such groups would form within any given country in response to the ETI encounter with a view to what might be done about adapting to the new knowledge. Should this happen it does seem a natural enough step for such groups to form some links with their cross-political kindred internationally. Thus it appears possible that the political reaction to an ETI encounter would be the emergence of a truly international multi-party system.

This is a necessarily simplistic view of what could occur. To attempt anything more detailed would be foolhardy as it would depend both on the nature of the contact and on the nature of the international political climate. The latter would be further complicated by that of the reactions of individual states at the time.

Not all countries are multi-party in political structure, but even in single-party countries the variety of opinion tends towards the formation of polarised groups. There may be some talk of 'ideological penetration' should any of the groups polarised into existence by an ETI encounter attempt clandestine communication with groups in other countries sharing their opinions. 'Ideological penetration' is also likely to be the kind of accusation levelled

against those who advocate that the problem be dealt with on an official international level. This is liable to be a factor where a large and powerful single-party nation might feel able to go its own way in dealing with the ETI problem; such might well be the case in either Soviet Russia or China. The more political parties which a country has at the parliamentary level, the more 'ideologies' which a national constitution can encompass, the less likelihood there is that this attitude against the international movements will be successful.

Would a standing conference of such groups be the body to hold the reins of a Pan-Human Contact Force? Would a regrouping of multi-national/multi-party movements be cohesive enough to tackle this problem? Perhaps not, but this *kind* of shift of political emphasis, if not this particular one, may be needed if we are to cope with the ETI problem in a mature fashion.

2 – Historical Perspectives 2

Inappropriate response to the ETI might prove disastrous.

The Opium Wars of 1839 – between Britain and China – contributed to Japan's anxiety about the power of the West. Unfortunately, although it gave China a far more evident and bitter display of Western military technology, the Sinic response was comparatively sluggish and directionless.

When change did come the impact on Chinese traditional culture was far more profound than the Amerinidian cultures experienced on exposure to the West. Like Japan, China had virtually held the European powers at arm's length for centuries. Certainly she had taken some token steps in the direction of diplomatic relations, notably by receiving a British embassy mission led by Lord Macartney to the Imperial Court in 1793. Sadly the mission returned home having made no headway.

With a surfeit of traditionalist thinking and behaviour, change is impossible except in terms of total destruction. Strangely enough, the same is the case with those who regard only the new as worthwhile (christened 'neophiliacs' by Christopher Booker[1]), to them the past is so much garbage to be junked. A society with the ability to change can accommodate both these extremes; one which cannot suffers the kind of destructive polarisation which China underwent.

The old corrupt values of the Manchu government were felt deeply even through the policies of gradual change attempted by the Kuomintang group. Millennia-old traditions generated in an atmosphere of desperation the only kind of change which was possible, the Draconian kind.

China was generally far too concerned with affairs within her vast borders, and the threat of overland invasion, to take the West seriously. Unlike Japan, she could not envisage conquest from the sea as a possibility. Ironically it was the Japanese themselves who came closest to conquering China during the Sino-Japanese Wars of 1894–95 and 1937–45 – from the sea, of course.

Almost one hundred years after Macartney's fruitless attempts to establish a British embassy in China, signs of profound change became apparent. Kuomintang, the nationalist party formed in 1891, aimed to modernise the sociopolitical structure of the nation.

A gap of half a century lay between this and the traumatic Opium

Wars which ended with the Treaty of Nanking, ceding Hong Kong to Britain and opening the 'Treaty Ports' of Shanghai, Nangpo, Canton, Amoy and Foochow to the United Kingdom, which then proceeded to dominate the China trade.

The difference was that, where 'Herodianism' was triumphant in Japan, China was distinctly 'Zealotist' in its response to the Western problem. There are other historical factors which can be argued as tending to incline the two East Asian states in the directions which they took. From the first contact with Portuguese traders in the early sixteenth century both countries diverged in many aspects of their response. The Chinese regarded the 'barbarians' with a mixture of amusement and irritation. The Japanese were keenly interested, particularly in Western firearms and the lucrative possibility of trade: they went so far as to start their own trade routes, faring as far afield as the straits of Malacca to the south and the Spanish Viceroyalty of Mexico across the Pacific.

Whether or not the Chinese were less naturally disposed than the Japanese to adopt Western ideas and technology, they certainly clung on fervently to their three thousand years of cultural tradition; they were unwilling to introduce any major changes until the structure collapsed, first partially in 1911 and then totally in 1945. By then a new Western format had arrived in catastrophic force. Communism had swept through the nation and was bent on changing every aspect of Chinese life.

Perhaps the two great East Asian nations are today classic examples of the West's two most controversial products, Communism and Capitalism, but Capitalism in Japan in unlike Capitalism anywhere else, as the Communism of China is also unique. Both have created something original from the material supplied by Western politics, technology and *mores*.

From the point of view of culturally surviving a strong impact, the Japanese seem to have been more successful. They seemed to understand the problem, and did something very positive towards reconciling the situation by establishing Shinto as the official state religion in 1882. This provided a strong reference point for the continuance of traditional elements in the lives of the people.

History 'tells' nobody anything. Many of us, however, succeed in reading just about anything we like into it. What we can be sure of is that in the past various civilisations, societies, cultures – call them what you will – have met, inter-reacted and consequently changed. On this basis it is fair to submit that when we make contact with or discover proof of intelligent life elsewhere profound changes will very likely result.

This does not mean that the history of mankind will then be ended; it does mean that history as we know it, of Man existing as the thinking centre of the Universe, will change its nature as it changes its context from the planetary to the interstellar.

The lesson here is that, no matter how tenuous or seemingly irrelevant the ETI contact proves to be, we should respond rapidly. We should adapt intelligently to its presence, altering what technologies or philosophies we can on a careful, selective basis. There should also be provision of a strong reference point for traditional arts and attitudes where we want them to survive.

When the problems of surviving an ETI encounter are discussed there seems to be a tacit consensus that it is cultural survival which is being discussed – and that cultural survival is desirable. What we must bear in mind is that there is also our survival as a race of beings to be considered. We may simple cease to exist as a result of ETI encounter, and not through any aggression on the part of the ETI, but through our own actions. ETI technology and philosophy may be so different that, although they are understandable, we destroy ourselves by employing both or either on a large scale. We may be forced to change our ways profoundly, as has modern China, simply to survive as a race in the Galaxy.

How important then is it to survive as a culture? Surely if species survival and cultural survival are incompatible, we will be intelligent enough to ditch the latter.

An illustration of this kind of problem can be seen in many African nations today. Most African states did not evolve from ethnic pressures but are derived from the colonial exigencies of Britain, France and Portugal over the past few centuries. Consequently, when attempts were made to run nations, whose basic political unit was the tribe and not the state, along the lines of European democracy, the result was frequently chaotic. The Belgian Congo bloodletting of the early 1960s is a frightening and perhaps extreme example of this. Certainly the *coup d'état* and counter-coup have enjoyed some popularity in Africa over the past twenty-five years. With this experience behind them, some political architects currently planning Zimbabwe hope to completely suppress tribalism as a viable force. They will even prevent resident Scots forming a Caledonian Society![2]

African tribal culture will have to go, either forcefully, as is planned for Zimbabwe, or through natural decay. Certainly the destruction of the clan system in Japan was quite systematic, even if the noble families did still retain wealth and some vestiges of political power after the Meiji Restoration. In Scotland, a country

deeply involved in the technological dawn of the West, it took place during the eighteenth and nineteenth centuries as a painful process of decaying credibility in terms of political compromise and an inability to cope with industrial society. This similarly affected the aristocratic sociopolitical hierarchies throughout Europe. Of course, the most forceful example of an antiquated structure being destroyed must remain China.

The ETI encounter problem can thus be restated as a human social problem. In our desire to emulate the best of what the ETI has in technology and social/political innovation we may be too hasty.

Let us take as example a case where it is apparent that the ETI will not treat with us because our political machinery is regarded as seriously underdeveloped. If we wish to deal with the ETI we have to change our ways. To change our ways, in a manner which they find acceptable, we have to understand their political systems, and these may be based on a social structure derived from slightly different psychologies.

For example, to enter the Galactic community we may have to live up to our own ideals of democracy, we may have to use the rapid development in computer and ancillary technologies to create a world state in which not only does everyone have a say in everything which is discussed, but everyone is sufficiently well educated to understand everything which is dicussed. Furthermore it may be imperative that everyone vote on everything. Compulsory true democracy would be an awesome task and the impact on present day political institutions would be *a priori* fatal.

Like the Asian and African societies, we would be forced to ditch our cherished and, in the case of the West, traditional institutions. These would be replaced by a system which, although seemingly derived from our own political heritage, in fact stemmed from the sociopsychological structure of a race from another star system who had more in common with, for example, Earth's dolphins, whales and other cetaceans than Earth's human beings.

Obviously a political transplant like this is culturally undesirable. What we would have to do is adapt the alien system to suit our own needs. One hopes we would, in time, adapt as successfully as have the Japanese, and that the time of change would be short. It would be pleasant if we could maintain the cultural links with our heritage at least as successfully as has that country. On the other hand, this may prove impossible and we may have to break with our past as severely as has modern China. And, just as that nation has today produced its own singular brand of Communism, so might we all

contrive to create a terrestrial brand of 'Galacticism'.

Would this be so tragic?

Either avenue means the end of our kind of world: the end of a world created out of solely human needs. This possibility has not always been apparent. It has, however, been noted by many historians that no one civilisation, no single culture, has a divine warranty of permanence. The late Jacob Bronowski expressed it as follows: 'We have not been given any guarantee that Assyria and Egypt and Rome were not given. We are waiting to be somebody's past too, and not necessarily that of our future.'[3]

The truly unchanging element in Man's Universe is, as Sophocles pointed out, the certainty of change. ETI encounter and all its attendant cultural repercussions thus fit well with human experience. If there is tragedy, it lies in the fact that vast numbers of intelligent individuals cleave to the *status quo*, and so must experience trauma when this crumbles. The avoidable unavoided is tragic; reconising the inevitable need entail only melancholy and nostalgia.

I believe that ETI will be encountered within the next few decades or perhaps centuries; for me that is an inevitability. I also believe that the distances between the stars are so vast that we will have the required length of time to make a well considered series of adjustments at a pace which will minimise potential traumatic impact.

Today we live in civilisations growing increasingly complex both in their infrastructures and in their cross-cultural relationships. Marshall McLuhan's 'global village' is a village in its ease of communication only. Although all nations on Earth would rapidly become aware of the ETI encounter once it was made public, the reactions to it are liable to be somewhat varied, in some cases quite dramatically so.

To return briefly to the 'village' analogy, we should remember that throughout thousands of years of human inter-reaction the village-type social structure remained constant. It is a structure optimised to deal with group relationships and has probably evolved with Man himself from pre-human days when our ancestors moved in packs. It changed little from tribal to feudal within a century of today. Today, however, there are profound changes taking place and many of these emanate from the industrial West.

The group with which an individual identifies himself within his society has always been defined by at least two affiliations: the social and the geographical. From tribal times these would appear to have been fairly clearly defined for most people in most cultures.

Even the impacts of acculturation across the centuries tended to leave the bases for group affiliation largely unchanged. Currently Western society is faced with an apparent disintegration of the family as a basic social unit. It is also experiencing 'social mobility', with people changing their 'peer groups' at a far greater rate than before. Kinship and class relationships are losing much of their old homogeneity and rigidity. Commuter suburbs of cities are referred to as dormitory suburbs, as work and leisure take place increasingly either within the teeming cities or within the secluded confines of the home. The village, tribal-based unit has almost vanished. It is being replaced; or, perhaps, as a structure it is changing into a more fluid heterogeneous arrangement of affiliations. As far as the geographical factor is concerned, there is today an increasing likelihood that a high proportion of an individual's friends will be found in another suburb, or even another city, rather than in the next street.

The requirements of aggressive industrialisation have forced these changes. In the West we have become acquainted with change and innovation over the past few generations. 'My' world and 'my' values are different from those of 'my father', even more so than the value differences which existed between 'my father' and 'his father'. Such is the nature of continual 'modernisation' that we are becoming rather unpleasantly aware of the need to either shield ourselves from it, or grow used to it, or prepare for it through anticipation. As we cannot be at all certain of the nature of an ETI contact, this fluid state of continual acclimatisation to growing diversity is highly desirable. So much so that we are probably in a healthier condition today to absorb the effects of an encounter than at any other time in Man's past.

There are other reasons for coming to this conclusion. Science fiction is as I have said riddled with examples of human chauvinism, of the good old Terran triumphing over the merely superficially superior, but deep-down inferior, alien.

Thankfully our 'global village' or communication system is acquainting those who inhabit it with the fact that, far from being inherently 'substandard', other cultures and other peoples have a great deal to contribute to the enrichment of personal and community life throughout the world. Indeed, the past thirty years has seen the emergence of a situation which has not existed for centuries, and which should held minimise the impulse to stigmatise. Once the West was simply the European way of life. The religious and political systems of Europe have appeared to be unchallenged in Western eyes ever since the Polish-Austrian allies

thrust the Turks back towards Asia in 1683. But since 1945 we have seen the emergence, not only of Russia as a non-Western superpower, but also of China, and of the Arab bloc operating within and through OPEC. Certainly it can be argued that the political and economic bases of all these are Western in origin; nevertheless, no one in the West would regard any of them as being truly part of the West.

So, currently, there are a number of highly powerful nations or groups of nations each with inhabitants whose daily lives differ quite markedly from those in the other countries. Thus, with the global-political position of any one of these being constantly challenged by the others, none can adopt an attitude of superiority to the rest. In consequence, the Westerner's automatic stigmatising of non-Westerners as inferior is growing ever more ridiculous in the eyes of the West itself.

If, then, we live in a society optimised towards change, and one in which stigmatising is becoming less likely, the next step in our ability to handle an ETI encounter is a widespread realisation among the peoples of the Earth that the ETI exists. After that has been accomplished, the problem which is unavoidable is the nature of the ETI contact when it occurs. Will it prove palatable?

It would appear to me that any state or society wishing to retain elements of its tradition and culture should not simply be capable of change but should be in the process of change when the encounter is made. The more profound the change process the better.

If we meet up with a culture which, like our own, has no previous ETI experience, there will very likely be enormous problems. The two cultures will inevitably be profoundly different, and both will be deeply rooted in their individual pasts. Assuming both we and they are of roughly equal status in knowledge, the encounter may not be unlike that of the Islamic and Hindu life-styles in North West India during the eighth century. These two religions are not, and have never been, mutually accommodating. It might appear that their followers have always been engaged in mutual conflict, but this is not the case. The Islamic Mughal Empires ruled India brilliantly, with much support from all quarters, thanks to the splendid statecraft of the rulers.

Where there is a great deal both we and the ETI can learn about the Universe, diplomacy will almost certainly come into its own. The human and ETI points of view on the problems which nature poses should encourage us to solve them in concert. This is surely the rational way to regard the 'alien'. The supremely irrational way is to ignore its presence.

Where the ETI has experience of previous contact, things should be somewhat better. They will at least communicate with a prior knowledge of the difficulties inherent in CETI. There is, however, a factor here which grows with the number of ETI contacts which have been made by the other before meeting us. Any Intelligence capable of interstellar communication on a fairly grand scale will probably be wiser than us and more knowledgeable in the techniques of energy handling and application. This would make us keen to study their communications in detail. We would be impressed by their achievement, and would thus view their culture favourably, tending to absorb aspects of it not directly related to the energy handling question. Among inter-relating human societies, acculturation frequently takes place most readily from the materially wealthy groups to the poorer ones. 'Zealotist' reaction tends to be strongest where there is a minimum of material benefit accompanying the cultural influx.

In the case of receiving a communication from a Galactic culture, the chances are that it would be fairly palatable. In order to accommodate the extraordinary varieties of ETI, such a culture would probably have many of the characteristics of the higher religions of mankind. Particularly, it would be flexible in many respects, capable of absorbing many local elements, and generally able to take on native (i.e., terrestrial) coloration. If it is optimised at all, a Galactic culture must be optimised in the direction of diversity, being by its very nature *multi*-ETI.

There will be problems, many of which will not be obvious at first. One of our main tasks will be to identify them, just as a Third World country moving ahead with a programme of industrialisation must understand the dangers of pollution and ecological destruction.

'Galacticising' Earth will only be complete when we as a race of beings begin contributing to the Galactic awareness as effectively as 'Westernised' Russia, China and Japan contribute to 'Western' awareness today.

We must not be guilty of a failure of nerve. It is absolutely essential that we determine long before the encounter is made that we are going to become a member of the Galactic community, a member with vitality and a new point of view on the Universe which we wish to add to theirs. We must determine to live amongst the starfolk as their peers.

If this is our personal, emotional and intellectual commitment to the future, then human civilisation will move forward to the stars simply because that is what it has set itself to do.

3 – The Dark Pedigree

Being human is the most natural thing in the world – to us, that is, and in this world. It seems to us that the human mind has achieved some kind of universal thinking standard, a standard which is the truly natural form of intelligence not merely here but throughout the known Universe.

It is an easy trap to fall into. As far as we can peer out into the vast reaches of space the processes of physics seem to be constant. There is a body of opinion that appears to believe that minds capable of perceiving those processes will have a common basis for building up a language for discussion, even if those minds have evolved on the planets of different stars.

The problem here lies in that the structures of the minds perceiving the same phenomena are not directly related to the phenomena under observation. An exploding sun, a nova, is not directly linked with the mind which observes it. Consider a volcanic eruption being viewed by both a buzzard and a giraffe. It would have no connection as an event with the design of the brains which registered it. Both brains are complex, having evolved over millions of years in highly specific ways. The interpretation of the event, its *significance*, would be dictated by the specific brain concerned.

To show how individuated significance relates to experience we need look no further than *Homo sapiens*, ourselves. Indeed it is imperative that we do look at ourselves in this light because thus we build up a little more of the human side of the Encounter Equation.[1] Then to balance out, on the principle that we are average, we attribute a similar level of complexity to the ETI's side.

We are at the furthest point reached in our evolution as a species. The same can be said for all the other species on our planet. The situation is not static because we all continue to evolve as species. We try out new variants, mutations. So let us attribute to the ETI a process which, if not natural selection, is at least as complex as our own.

So far there have been many organic molecules discovered in the clouds which lie between the stars.[2] There is even some evidence from meteors that the very 'building blocks' of life have evolved outside the Earth and should probably appear through known processes on planets similar in a number of respects to Earth in its primordial state.

There is always the possibility that through undiscovered processes mental life can spring fully formed from the chaos. This would open an area of correspondence between ourselves and any other entities with a long developmental history. Sharing this factor may prove a common ground whereupon we might start forming the basis of a closer liaison and perhaps ultimately some profound communication.

Of course, they will not be related to us genetically. My opinion of those writers who would have us believe that we are the result of genetic engineering by an ETI is that they explain nothing and open no new possibilities. Some are sincere, others are not and there is the odd one here and there who appears to be crackers.

If there are differing forms of developmental history then each may well throw some kind of light upon the other, enlightening us, and hopefully the ETI, about the nature of our origins in the Universe.

Evolution, for example, has a number of restrictions as we know of it on Earth. It can and does pass on the mechanisms which permit us to learn from our environment but it does not pass onto our offspring that which we have learned. This process, the inheritance of acquired characteristics, or Lamarckism, may well be present elsewhere in the Universe. Beings designed along these lines would have a great number of physical and mental differences from mankind. Their psychology is virtually unguessable and their rate of acquiring data about their surroundings would be astounding to us. Perhaps even describing them as a plurality is wrong. They may be 'It', a multifaceted organism distributed throughout a vast number of individual bodies.

How would such a mentality view us? Perhaps we would seem like some very odd freak of nature, if It could imagine us at all. To It we would lack the basic qualities requisite for an AML (advanced mental lifeform) and, if It speculated on the existence of creatures like ourselves, we would be dismissed as a statistical impossibility.

There simply are no hard facts about ETI. Reflections on its nature are at best hypothetical. Presently ETI itself is an hypothesis and an *ad hoc* one at that. The very discovery of its existence, should it happen and hopefully it will, is going to change our picture of the Universe. It may well change it fundamentally if alternative forms of developmental history are established.

Should this happen it will hardly be tragic. One of the points about knowledge is that it is relative. Theories happen to explain how various events seem to be inter-related at a certain point in time. They are rough sticks which we use for measuring the world

about us and which we throw away when better, more accurate, ones become available.

It is important to make this clear before going any further because, although I am going to talk about evolution for the next few pages, evolution is not a fact: it is a theory. If a thesis is published tomorrow which explains everything which evolutionary theory does and more, a great deal of the following wordage may have to be ditched, or at best revised.

The first point which has been made by numerous writers is that the number of chance events which went into the evolution of Man is so vast that there is virtually no chance that Man as he exists on Earth exists anywhere else in the Universe. A lifeform evolving on another planet would certainly go through an equally vast number of chance events in its development. It would be similarly unique in the Universe. What we have in common with the ETI is our singularity.

What constitutes a human being is more than a mere physical collection of arms, hair, bone, nervous tissue and so on thrown together at random. Like every other living creature on Earth a person has a profound intimate relationship with his environment, which naturally includes all other life coexisting with him. This is not a closed biologically exclusive arrangement. Volcanic action, earthquakes and ice ages, along with a catalogue of other non-biological activites, tend to act on lifeforms rather than be acted upon by them.

When a species can survive most types of natural catastrophe as a species it is well on the way to establishing its own private ecological niche. This is why the delectable little oyster looks and very likely tastes pretty much the same as it did one hundred and fifty million years ago. Every new generation which appears has a few wild variants thrown in by nature. These might be regarded as natural experiments. Most of them fail. In the case of the oyster they have been failing for some considerable time now because the oyster is about the optimum design for the conditions it has experienced since it snuggled into its particular niche.

Fortunately for us, the various forms of animal life which were the precursors of Man had a higher success rate with their 'natural experiments'. Conditions would change and an experimental model, a mutation, would prove to be particuarly good at handling the new set of conditions. This would continue as the various changes took place in the world around them.

One of the crucial factors here is that an evolutionary adaptation on the part of one species would be likely to lead to

adaptation in others. If, for example, a small mammal changes from foraging for food by day to night-time, the predator, who relies primarily upon it for food will have to adapt. It can either become a night hunter or it can change its design so that it is better equipped for hunting another prey by day.

All this is done through natural experiment. It is a highly wasteful but nonetheless successful process, which has inter-related the development of life on Earth for the past several billion years. This developing inter-relationship within the consequently altering environment is a crucial element when we come to the ETI problem.

If we assume that a system similar to evolution has been responsible for the production of an extraterrestrial AML, we assume that the developmental history of the organism is likely to be about as closely tied to that of its environment as we are to ours. It is not just the ETI which is singular but the environment which has produced it, and the whole sequence of events which has brought that environment into being.

All living creatures that we know of relate to their environment through their activities, their behaviour. This is just as subject to natural experiment as the physical design of the creature. When there is a favourable combination of design and behaviour there is a major change taking place. A bird's wing accurately reflects properties both of the air in which it operates and in the way in which the bird operates the wing. This is an illustration of environment, design and behaviour successfully integrated.

What then about the design of Man? Like any other animal his physical and behavioural aspects are the expression of his relationship with his particular environment. Behind this there is an impressive history of development stretching back as long ago as life itself on this planet.[3] It would seem from this alone that he is closely bound behaviourally with the limitations of his unique environment.

The instructions which each member of a species carries in every cell of its body for the duplication of that individual member are held in the genes; Man is endowed with more genetic information than almost any other known creature. This information is not simply a design blueprint: it is also an operating manual. The basis for the individual's intricate interaction with the environment is coded there.

It seems ironic that the animals which have a greater ability to learn need to have a greater store of genetic information. On reflection this does take on at least a patina of logic. As time passes, animals appear to have an increasingly sophisticated relationship

with the world in which they operate. This is reflected in their design. Even the growing sophistication of behaviour is reflected in physical design.

The design of the brain is one of the keys to the recent evolution of Man. This brain, like the rest of the human being, has a pedigree stretching into antiquity. At no point back down that branching path does it even touch the development of an ETI brain. How could it? It was never involved in the equally complex and distinct dynamic changes within which the brain-equivalent of the ETI came about.

Man's ability to modify his behaviour and to learn have come about within the context of the changes on planet Earth. The ETI's abilities will have come about within the context of environment *x*. Earth and *x* are quite distinct and different. There will be a great deal which they have in common. There will be common chemical elements and compounds; the physics of *x* will be the physics of the Universe. However, the abilities which the ETI possesses to appreciate these factors will be differently derived from those of Man. They will be closely linked to the ETI's developmental history within *x*.

This does not mean that there can be no possible communication between us; but I hope that it does show the problems of CETI to be more complex than many would believe them to be. There is a tendency to attribute through analogy the developmental history of Man, our own pedigree, to the ETI. Analogy can be dangerous. Here it is disastrous.

In one very learned text on CETI there is a discussion about the rise of technical civilisations.[4] It is based on a close study of the rise of human civilisations and the problems which could be involved with a society reaching the technological level. Personally I think that this is entirely the wrong attitude to adopt. Even noting that human civilisations had to undergo a variety of transformations before attaining their current states is hardly enlightening. It tells us nothing about the ETI which we cannot already surmise from its having been subject to a system roughly similar to evolution.

The really dangerous assumption to make is that the ETI is *civilised*. Attributing a corresponding level of complexity to their side of the equation does not presuppose the same or even a similar system.

What is required by any mental lifeform in order to expand the results of its mental activities across the cosmos? Is civilisation the only likely route available? If this is so, then the reason why we have yet discovered no convincing evidence of ETI is that we are

certainly alone. The sequence of events which led to Man was singular enough without adding to this the further socioanthropological phenomenon of civilisation.

This assumption, that ETI will have the behavioural trappings of Man in a number of respects, seems quite bewildering. The very people who discuss it acknowledge on the one hand that Man is unique by virtue of his evolution and on the other make quite a point of illustrating how similar to him they expect ETI to be.

Let us anticipate that the non-human mind expands to the stars, if only by virtue of its electromagnetic excreta as we are doing. Even so, we still cannot assume that the behavioural systems which brought the interstellar urge into being are similar. A skinned rabbit is a skinned rabbit but there is more than one way to skin it.

The ETI will be an AML which has achieved its advanced status by taking a different path from our own. Consequently we will find its mental activity to be rich but bewildering, and certainly exotic. Thus an encounter will not be an interaction between intelligences as we understand intelligence. Our mental structure, which defines our mind's activity and thus what we describe to ourselves as intelligence, will not be the same as the equivalent structure/systems in whatever we meet. There will be two interpretations of the encounter. One will be ours, that which we describe to ourselves using all the information which our mental equipment is dealing with as 'objectively as possible' from the situation. The second will be the alien form, that of the ETI, equally sophisticated but in many aspects differing profoundly from our own. So in some ways the two of us will be roughly akin here to the buzzard and the giraffe watching the volcanic eruption.

A single event will mean different things to us. Our hierarchies of significance are going to differ in many ways. These hierarchies are involved in the very moment-to-moment experience of existence. Consciousness as we understand it may be a mystery to the ETI simply because it is not relevant to it.

The confrontation with ETI or the products of ETI will prove to be a most startling revelation to Man. We should be prepared for a shock. We should be prepared to deal with the possibility that an advanced seemingly technological ETI will be far more different from us in its modes of perception and cerebration than we have so far led ourselves to suppose. For humans the existence of an ETI with what we interpret as a technology indicates that the ETI is a lifeform which understands scientific principles, logic and mathematics; it would therefore seem that here we have something solid for initiating a basis for

communication. This belief is fundamentally misconceived in my opinion.

It has been pointed out that there are certain aspects of the Universe which remain constant and are not subject to individual interpretation. This is true. It has been posited that we may use these as a basis for communication. This may well be true in part. The wavelength of hydrogen emission in the electromagnetic spectrum (21cm) has been suggested as a likely one to be used by ETI attempting to communicate by radio across interstellar space. This appears to be reasonable; so far so good.

The problem arises in what follows. We know that thinking is a human activity and science is one of its products. Science is a way of thinking. It is a way of thinking particularly concerned with pushing forward the boundaries of human knowledge. If we pick up a complex signal – say on the 21cm wavelength – and after considerable testing build up a credible argument for it being artificial we are liable to believe that, as a technological source is responsible for it, we will be able to understand it. This is because we think that the source could not send the signal without an appreciation of mathematics and logic, as mentioned above.

Our minds, even at their most abstract, function with reference to the terrestrial connection. We have evolved in such a way that we form symbols and extract significance from the environment. These we combine in what we call relationships. We are good at playing with relationships. Other animals on Earth, particularly mammals, appear to have something of this ability, too. Certainly the other primates have some symbolic conceptualising ability, as has been demonstrated with chimpanzees who have been taught sign language and the ability to communicate with human beings *via* a computer.[5]

The nature of the problem is better illustrated as we move further away from Man, rather than closer to him, in the world of animal life. The cetaceans, the dolphin-whale family, are well known examples of animals with highly complex and large brains. It would appear, however, that the newer areas of their brain, the neocortical forebrain, developed in the sea, a quite different environment from that in which Man's appeared. Zoologically the chimps are our very close cousins whereas the cetaceans are much more distantly related. The zoological and evolutionary distances are illustrated in both the appearances and behaviour of these animals. Accordingly, it should not come as too much of a surprise that we find it comparatively easy to communicate with the primate and extremely difficult to communicate with the cetacean. To reiterate

what I said before: the developing brain is a reflection of the creature's adaptation to its changing environment. With a history of millions of years in the oceans of the world it is only to be expected that the mind of the cetacean is very different from our own. This is going to be particularly true of the area of non-genetic information, information which the environmentally produced brains extract as being significant from the Universe as they see it.

In other words *significance* is the key. What is of significance to the whale and dolphin may be of little if any significance to a human being. Those cerebral structures which attribute significance may well have developed similarly in a number of respects, particularly as they are both mammalian brains in this case. This does not mean that the particular significances extracted are the same.

As far as structure and function are concerned we can expect a good deal of correspondence. Similar structures should have fairly similar functions. To use an analogy, let us consider a machine for transporting human beings through three dimensions from one point to another. The vehicle will probably have a shape dictated by the properties of the medium through which it moves. Other properties of the medium will be utilised by the propulsion system and the humans transported within will be protected from the vagaries of the medium by a closed and pressurised environment. This one description of structure and function applies equally to aircraft and submarines. The reasons why these machines cannot operate in each other's environment are fairly obvious. There is nothing of particular significance in the other's environment which allows the one to operate within it successfully.

It can be dangerous to extend analogies but, if we humans consider ourselves to be cerebral Space Shuttles, the chimp is an old turbo-prop aircraft and the dolphins are way down below the waves, nuclear subs perhaps.

This is a better explanation of why the dolphin-whale minds have no civilisation than the fact that they are not equipped to handle tools and thus actually create tools. Civilisation is a by-product of the *human* mind and an illustration of *human* behaviour. To expect the same from the cetacean mind is naïve. I will go so far as to say that civilisation is insignificant to the minds of dolphins. If we wish to come to terms with them there is no point in studying them in 'controlled' environments. These probably have significance only to us, not to them. If we seriously seek to understand we must join them in their world. Long, close observation will not be enough unless it is done within the environment where these creatures interact optimally with the Universe. If we would understand them.

we must not expect them to set up a dolphin embassy in Sydney harbour.[6] We must establish the embassy, not by the shoreline, which is our symbolic, and thus by definition human-interpreted, division of the two worlds of man and cetacean, but place it where it cannot be ignored – travelling with these creatures, among them through the oceans of the world.

It is important that this be done. Discovering the nature of the complex dolphin and whale minds is a step towards the understanding of how best we can deal with the much greater problems of understanding mental life in general, our own in particular and that of the ETI, should we ever contact it.

Broadening our concepts of what mentation is and what it does will lead us into many new philosophical realms which are currently great fun for the science-fiction writer (particularly Ian Watson[7]) but little considered by the scientists working on CETI. The simple chain of consequences which I would like them to take note of is as follows: non-human beings have non-human minds displaying non-human behaviour.

The behaviour which is derived from our own dark pedigree has been the subject of considerable debate. It is important that we determine as closely as we can how the human being is motivated, what relevance genetic instruction has in coding behaviour into the brain, and to what extent the structure of the brain itself delineates the boundaries of human behaviour. Civilisation, human society and culture are all products of that unique being, Man. We cannot expect them to exist elsewhere in the Universe any more than we can expect Man to exist elsewhere.

What we are liable to discover out there are complex and exotic entities which will appear, at least primarily, utterly bewildering.

4 – Come Up and See Me Sometime

If the ETI has a considerable amount of experience in encounter we can expect to be led along the path, if not actually up the garden path, by a being much more subtle than we might initially suppose.

A veteran AML preparing to open relationships with emerging mental lifeforms might regard a knowledge of the contactee's psychological bases to be desirable. Playing around with junior's behavioural building blocks might be one of the general approaches to the whole problem of minimising and re-channelling violence if it is common amongst the 'youngsters'.

Although we humans readily identify the biological bases of behaviour among other members of the animal kingdom we find difficulty in ascribing this perspective objectively to ourselves. If hubris is the stumbling block then the ETI viewpoint on ourselves should dispel that effectively once their presence becomes known to us.

Remember, to an ETI *we* are the aliens, the bizarre creatures inhabiting a strange and mysterious planet. To them we are the dominant lifeform of Earth, the animals who have adapted most successfully to the stringencies of Nature as present on this peculiar word. We have done this due to the singular nature of our mental activities. Physically an ETI would class us as a primate along with the other apes. The big problem would be in the comprehension of our behaviour.

Obviously if you or I or anyone wishes to become accepted as a member of a community we should adopt the standards of behaviour which are expected in that community. Likewise, if we wish to establish diplomatic relations with another country, it helps to know how one is expected to behave socially; and, should one be expecting a fairly long stay in the country, a more than passing acquaintance with the language is highly desirable. An ETI wishing to establish relations with the human race might therefore wish to understand our biological-behavioural language or 'biogrammar',[1] taking as a reference our fellow animals here on Earth.

Here they would have a tremendous advantage. We have no knowledge of the biological bases for ET behaviour. As we cannot assume that they are similar to our own, CETI specialists should take great care about what they mean when they refer to 'advanced technical civilisations'. In their estimations of the numbers of such

societies they frequently refer to the proportion of them which communicate by means of radio or other electromagnetic media. A further factor is the lifetimes of such societies and whether or not many or few may destroy themselves.

The surviving of potential technological self-destruction strikes me as a peculiarly human consideration. If all AMLs are quite distinct in their natures then the nature of the problems which they create for themselves are liable to be solved only within their own sphere of understanding. The concept of a Galactic Agony Column where all cries for help are succinctly dealt with strikes me as being anthropomorphic.

There are those who seek to justify CETI in exactly these terms. How might another AML capable of studying us in something like our own terms regard the human desire to search outwith oneself for answers to internal problems? In this instance, CETI seems like one of the oldest forms of communication with a very advanced lifeform; it sounds like prayer.

We cannot assume that there are 'advanced technical civilisations' or even 'scientists' amongst the other AMLs in the Galaxy. We should not even assume that there is consciousness as we understand it and are aware of it. This would appear to be governed by the limitations of our brains imposed by that genetically governed structure evolved out of innumerable chance events happening over millions of years.

When we are awake, conscious, our brain is in its behaviourally active mode. To use an analogy with computers, when we talk of consciousness we talk of the condition in which the behaviour programmes of the brain are 'on line', available; the functions of the brain structure are ready to be used. This expression of structure is completely absent from all known forms of vegetable life because there is no structure. This does not mean to say that wherever there is a structure of this nature it will be similar to that evolved among animal life on Earth. The structures will differ and the expressions of them will differ.

We can expect no scientists elsewhere and no civilisations in terms which we currently appreciate.

What another AML must have is equally complex structures generating equally elaborate functions, as sophisticated as our 'consciousness' but different. As we have no worthwhile analogies there is no way of realistically anticipating what these may be. What we can appreciate is how *we* might bridge the gap and assume that in the case of some ETIs there will be a function analogous to this

Should it be able to, it may study the behaviour of Man

comparatively with that of other animals which surround us. If it is very different from us it may have to start with the basic differences between plant and animal at the level of single-celled creatures and work laboriously up: this may be necessary in any event, considering the complex interaction between all living beings on the planet.[2] Eventually it will apreciate us within the mammalian and then simian frameworks. On that basis most of the guidelines for our behaviour will have been laid.

They will then understand just how different they are from us and their world is from ours.

Bearing this in mind, how should we react if an ETI does establish contact? We should realise immediately that any response we might make could be either misunderstood, incomprehensible, or anticipated. By 'anticipated' I mean that the ETI would have done its homework and learned our 'biogrammar' before opening the dialogue.

To do the homework thoroughly much of it would have to be done *in situ*, which would mean that the ETI would have to visit the Earth unobserved. Again we return to the unfashionable hypothesis of interstellar travel. We will continue to return to it. Why? Frankly I find the concept of a Pan Galactic Radio Network smacks of CBS or the BBC expanded to Galactic proportions, and equally farcical. Without an appreciation of the 'biogrammar' of the beings to whom a broadcast is being directed, assuming they even find radio desirable in the first place, the chances are that the message to the stars will be at best garbage and at worst frightening. Only through rigorous study of the lifeform concerned, probably at close range, can we (or an ETI) make effective attempts at communication.

At our present rate of technological progress we will have the capability to send a probe to another star system some time in the twenty-first century. Consequently, to talk in one breath of civilisations *thousands* of years ahead of us and the impossibility of interstellar flight in short-sighted.*

Many AMLs through the Galaxy may not be interested in – or even able to think in terms of – interstellar travel, but mobility between the stars has probably been accomplished many times in the history of the Galaxy. My own contention is that the motives for the mobility are probably very different from one another and from our own.

I will assume for the purposes of the present argument that an

* See Appendix 2.

ETI has been present in the Solar System for some considerable time and is studying mankind with a view to making a contact. What form would the encounter then take?

There are aspects of the human being's behaviour which would have to be taken into account, such as xenophobia, aggression, fear, suspicion, hypocrisy, cunning and lying – to give but a few examples. Naturally an encounter would have to be staged in such a manner as to give as many psychological reassurances to mankind as was feasible so as not to trigger, perhaps quite literally, an unfavourable response.

There should be evident, right from the start, some aspects of the ETI which make them interesting to us. If these are not immediately apparent, then other artificial aspects would best be manufactured to engage our interest. The very fact that they are ETIs and have interstellar capability will of course be interesting as such. What I am referring to is the presence of the ETI. If, for example, it is drastically different from us physically (e.g., gaseous or microscopic) an artificial physical form might have to be used until we were ready to accept the truth about the physical reality.

Note, these artificial physical forms would be employed to help the human through the psychological doors of encounter. If this is so, then there is no reason to suppose that the ETI would stop short at partial deception. A wholly artificial encounter designed specifically around the needs of the human psyche would be the ideal for an encounter with us. If they have learned our 'biogrammar' sufficiently well they will know this. If they are the equivalent of a few thousand years, or even a few centuries, ahead of us they should be able to put their knowledge to good use.

For the above reasons I feel that our first encounter could be idyllic from our point of view, *should an ETI know of our presence and be moved to contact us*. Not only would our psychology be utilised to defuse potential conflict, it would be applied to further the ends of the ETI. In an encounter we naturally assume that the ETI wants as satisfactory a contact as possible. What that would entail from the visitors' own point of view we cannot say, but, if they wish it to be satisfactory from our point of view, we can hazard a few guesses.

It would be nice, for example, to run into a particularly likeable group of ETIs.

The TV programme *Star Trek*[3] has gone through a fair gamut of ETIs and, however unsatisfactory most of them may be, some indication can be had from public response to the various 'aliens'

which kind would possibly be the most palatable to the general public.

There is of course the remarkable dispassionate but caring Mr Spock. What makes Spock appealing? He has an ethereal quality about his personality, a detachedness which seems to border on the divine. This makes him in many eyes as a superior being. Such a being would certainly be attractive to those who look to the heavens for a measure of divine guidance. (It has been suggested by Jung that the UFO cult is in fact an attempt to replace God with ETI which is superior and benign.)

If a throng of Spock-like beings ('Vulcans' in *Star Trek* parlance) did appear in space ships orbiting about the Earth the reactions would probably be rather mixed. There are those among us who do not like the idea of being inferior to anyone or anything except, perhaps, God. Being faced with a race of superior creatures implies that we are faced also with a superior authority. Would governments feel that their subjects saw the ETI as an ultimate supra-governmental court of last appeal beyond the Earth? They would certainly feel that their own authority was undermined and thus tend to regard the ETI with some measure of hostility. Furthermore, although paragons may be admired it is rather difficult for the rest of us flawed mortals to identify with them.

So if there is, somewhere in the annals of that immensely successful piece of popular television, an indication of how the ETIs may approach us, it lies only partly, if at all, with the Spock image. In fact, one particular episode evoked an immense response to its 'alien' lifeform which had nothing to do with the Spock-type appeal. These creatures were not particularly intelligent at all.

They were called 'Tribbles'. They were utterly lovable. The urge not to harm them, never mind destroy them, was the point of the episode in question, as they were posing a threat to the starship due to their excessive breeding habits.

I think that here we are on much more likely territory for an ETI encounter designed by Them around human psychology. If the encounter cannot avoid being a provocative occurrence then let it provoke this particular kind of response, not just pro-ETI but one which brings out a fondness from us, creates an emotional bridge with the visitor.

The forming of emotional bridges or 'bonds' is an integral part of our biogrammar. It is so basic that it may prove accessible to them. Observation would show it to operate through a vast section of the Earth's animal life, as I have said. They might be able to deduce the detail of human bonding from the general activity.

So what kinds of bonds are there and how could the ETI go about employing them in an effective manner?[4]

The most difficult bond to create for them would be the parental one. It would be a tough assignment indeed for an ETI to somehow persuade the human race that we brought it into being and try thus to elicit a parental response from every one of us. A 'pseudo-paternal' response, on the other hand, might work. This would be to evoke the same or similar kinds of feelings which are brought out in the parental one. This is similar to what the Tribbles did. They evoked a feeling of wanting to care for the helpless 'little things'. The parental response is one which encourages us to protect and cherish the 'child' object which can be either a child or a pet or another human being (who is at least nominally adult).

There is a problem, of course. We are liable to find it difficult to believe that an ETI capable of interstellar flight is a helpless 'little thing'. The technologies involved in such an engineering project are daunting enough for us to regard the ETI as a quite formidable 'little thing', no matter how cute and 'Tribblish' it may appear. Nor will a combination with the Spock image help any. Where the Spock image is aloof, the Tribble image is cosy, and the combination of a cuddly Spock or an aloof Tribble nullifies the effect of both.

The bond will have to be such that we find the ETI acceptable and attractive. Only the most perverse humans want to destroy that which they love. They tend to pursue and make room in their lives for love objects, be they child, spouse, the music of Beethoven or the game of golf.

And the game of golf has to be taken seriously. It is an example of a vast number of human activities which have arisen out of an urge on the part of human males to bond together and form groups from hunting parties to football clubs and all sorts of societies with dark and secret initiation rites. This is the male group bond.

It seems unlikely that this would be used by the ETI in other than a reinforcing context (which I shall come to shortly). It is a trifle surrealistic to suppose that ETIs will suddenly appear in the sky above and make themselves known to us as orbiting representatives from the Tau Ceti chapter of the Masonic Lodge.

Possibly the best strategy for bonding will be one based on sexual lines. This is not as ludicrous as it may at first sound. Enough investigations of human sexual proclivities have been made to show that what a human finds sexually attractive is dictated by that person's emotional development within his or her personal and/or cultural environment. Our sexual appetites, although generated by

our reproductive process, are not dictated by it. Happily for us as a species this discrepancy has not proved so far to be of major proportions.

A humanoid designed carefully to accommodate many of the features prized in the sexual aesthetics particularly of the West would prove a most attractive creature. It should also have built in some of the features which evoke the parental urge; these have a good deal to do with the distribution and relationship of the facial features one to the other. Large, dark 'wet' eyes are, for example, generally regarded as being attractive. We seem to find them so in animals, children and other adult human beings – particularly of the opposite sex.

It would be important to make the 'alien' at once attractively human-like but not wholly human in appearance. Were we to encounter another group who were apparently human, our suspicions would be aroused immediately, as we know how unlikely it is that there could ever be another race of human beings elsewhere in the Universe. Consequnetly, there would have to be differences – and these themselves would make it less likely that we would endow the ETI with the duplicity which we associate with our fellow humans.

Yet these differences, too, would have to be oriented towards making the custom-built being attractive. Give them then the short reddish pelt of a deer, say. Give their facial features doe-like or feline aspects. Make them on average perhaps slightly smaller than a human being, so that they do not overawe *Homo sapiens*. Let them move with a svelte grace of step and speak softly, laugh musically and frequently. Above all let them be able to smile prettily.

This is a rough sketch and many males will disagree about how attractive a bonding object is, particularly in sexual terms. But the general principle is what I want to put across here: giving the bonding element as widespread a shotgun blast as possible so that something is hit somewhere in everyone – or most people – who encounters the contact 'fronts'.

The initial encounter itself is of great important. The ETI presence should be made known in such a way as to promote a minimum of panic or hasty reaction. I am specifically dealing with the presence of an interstellar spacecraft of non-human origin being introduced into human consciousness. How would it be done?

Coming on it 'cold', as it were, would possibly be a traumatic experience. We would have to be weaned in through acceptable

channels. Currently the only acceptable channel is that of the radio signal from a distant star system. Should the ETI decide to incorporate this as a feed-in to the situation in the near future – say within the next fifty years – we would find it quite palatable.

Let me construct a scenario.

Radio telescopes are alerted to the fact that an apparently artificial source has been discovered in a part of the sky thickly populated with likely stars. It is roaring so loudly on so many frequencies that it is virtually impossible to miss. The signal is repeated often enough for it to be recorded before it ceases. Analysis of the signal indicates that one small section is a description of our Solar System but with a peculiar emphasis on the fifth planet, Jupiter.

Some inquisitive little radio telescope is going to point at the giant world to see if there is any response. Needless to say, there will be. A new and obviously artificial radio source will then start beaming out from Jupiter. Closer investigation will show that the source is actually in orbit about that world. We will then try contacting the artificial source by radio and, of course, we will be quite successful. The source will be far enough away not to be regarded as a threat, so mankind will ponder what to do next.[5]

The chances are that we would decide to send an unmanned fleet of space probes out to observe more closely. In any event the ETI in Jupiter orbit will send us a clear unequivocal invitation to visit them at Jupiter. They will not indicate any intention of coming across the asteroid belt to the inner planets. They may even state specifically that they have no desire to do this, or cannot do it because their ship is crippled or some other excuse. Principally they will be staying at a safe distance. 'Safe' for us, that is, in terms of human psychology.

And, of course, eventually we will go in person – sooner rather than later, I think. What will be miraculous will be the rapidity with which the ETIs pick up the major spoken languages of the human race. I would even go so far as to suggest that they insist that the expeditionary crew consist of particular types of people whom they know will be especially susceptible to bonding at physical encounter. Of course they will know us well enough to disguise this motive.

Imagine a group of sex-starved young bachelor males boarding an ETI ship and finding themselves in the company of the most physically delightful and exciting beings they could imagine. Bonding individual human personalities to individual ETI fabricated beings would then take place. The men would be told a lot about the true nature of the Universe and introduced into the

mysteries of the Galactic Culture through an initiation ceremony which bound them to the fraternity of Galactic Minds. Some hypnotic implants could be used here, but the chances are that they would be entirely unnecessary. This secret-society bonding appeals to something basic in the social equipment of male humans, and our ETIs would certainly not overlook something as useful as that.

As the decades passed the ETIs would be accepted and their crippled' ship in Jupiter orbit regarded as an embassy of an alien power within the Solar System. Then slowly, gradually and gently the ETIs would be able to introduce the truth about themselves to the human race in a very controlled environment. At this point the scenario must end. There is no way of knowing what the ETI motives are likely to be. We do not have the opportunity of closely analysing their biogrammar.

One thing is fairly clear though. They will introduce us to a new and almost certainly uncomfortable perspective on what it is to be human and evolving in a Galaxy brimming with myriad different forms of mental life.

5 – A Meeting with Tomorrow

So few people find evolution a magical and exciting subject. This has often left me quietly mystified. I wonder whether or not it is I who have a peculiar perspective on the phenomenon of life ever-changing. Most people regard evolution in the same light as they regard the path that leads up to their front door: they see it as something external to where they live, static and not really all that relevant to what goes on on the other side of that door. But to me it is a roller-coaster ride carrying us all from the black silences of prehistory into a roaring future. There is something heady and perpetually relevant about it. Teilhard de Chardin put it like this:

> it is a general postulate to which all theories, all hypotheses, all systems must henceforward bow and which they must satisfy in order to be thinkable and true. Evolution is a light which illuminates all facts, a trajectory which all lines of thought must follow ... [1]

And yet so many of us consider Man to be the supreme point of evolution. With us it has achieved a self-conscious being. From this point evolution leaves off in the biological sense and cultural evolution takes over.

Homo has been around for better than a million years and *Homo sapiens* for over a quarter of that time. Certainly it can be pointed out that there have been no major changes in the human anatomy in the past fifty thousand or even hundred thousand years. It would be foolish indeed to imagine that nature has therefore 'switched evolution off', so to speak. The shark has been around for around fifty million years in more or less its current form and some of the social insects have been around for considerably longer. Are we thus to imagine that those creatures share some kind of evolutionary peak with us? Of course not. Those animals have simply adapted to a highly efficient form, their optimum evolutionary status. Whenever major mutations appeared they were generally less adept at surviving that the original, and accordingly died out.

Has this happened with Man? There are those who claim that we may evolve into particular types of beings. Generally the argument runs along the lines that, as we sow, so shall we reap. The advocates of what I shall call natural evolution tend to paint similar portraits of the beings we are to become. The natural evolutionists argue

that, as mental activity is one of the main factors which has put Man in a position of dominance over his fellow creatures, natural selection will favour the bigger and better brains. As such appendages as arms and legs become less and less important, due to the facts that we will have artificial transport to zoom us around everywhere and machines to perform all of our physical work for us, our bodies and limbs will become thin and frail. In fact, we will look like nothing so much as giant babies. Hair will vanish – as it almost has already. Our heads will be enormous. And physically we will be virtually helpless without the aid of our machines.

I was very pleased to hear that this rather disgusting description of the *Homo superior* is in truth rather an unlikely one. Apparently the width of the female hip bones is critical where it comes to the size of the child's head. That width has already spread as far as it realistically can. To spread further would entail a change in the stance of the female of our species. She would have to go around on all fours. Appealing as this may seem to revenant anti-feminist males, this is unlikely to meet with universal appeal.

To compensate for this fact, the human brain has probably become increasingly complex and convoluted over the past half million or so years. This process of wrinkling up the brain's 'skin' to increase its surface area also seems to have gone just about as far as it can. So, where do we go from here?

Science fiction has provided a number of suggestions. Most popular amongst these is that of acquiring extrasensory powers. These may very well be just around the corner. Soviet research in the field of ESP is extensive, and the whole field appears to be gaining some measure of respectability against great odds even in the United States. Of course, a large section of the scientific community is whole-heartedly in opposition to anything even smacking of the paranormal.[2] This is healthy. If the paranormal is scientifically valid it will come through eventually; if not we will be saved from our own attempts at wish-fulfilment and a grand variety of fraudsters.

If future human evolution lies with the paranormal there is currently very little that can be said about it. Certainly, if extrasensory powers do become widespread, the impact upon social life will be at least as devastating as television.

Then let us assume that Man has reached very rapidly indeed the condition of the shark; say that we have reached a dead end so far as potential for further physical evolution is concerned. We are then left with the cultural evolution which I mentioned earlier. Where does it go from here?

Cultural evolution has so far taken us from living in tribal or pack units in or around caves to the heights of sophisticated social life today. These changes have transformed our lifestyles dramatically, particularly over the last twenty thousand years. The great ice masses lost their grip on the planet and Man gained his.

There is no reason to suspect that the changes which cultural evolution will subject us to over the coming twenty millennia will be any less profound than those of the last; in fact, should we survive in any form, they are more likely to be even more fundamental in their impact. They will change the nature of our social organisation quite as thoroughly as they did before. But, more important, they will also change Man – and more drastically in his form and nature than in any change the world has seen in the seventy-five million years or so since the Age of Mammals began.

We are now in a position to see physical and cultural evolution merging at that point on the horizon towards which we are rushing.[3] The amalgam into which they are about to be synthesised bears closely on our attempts to understand the problems posed by ETI encounter. If, for example, I am wrong about ETIs being basically different from one another in the format of mental life then they will probably be somewhat similar to one another and to ourselves.

We will in effect be, in that case, encountering the equivalent of the human race at a different point in its development. The Galactic timescale is so vast that even the closest encounter is likely to be with a race ten or twenty thousand years ahead of us; in effect, this amounts to us meeting our descendants of many millennia hence. So at this point it is necessary to investigate the probable future of mankind and particularly that point on the horizon where our evolution reaches a critical stage.

Evolution means change. Most people do not respond favourably to the idea of change at all. If they do, it has to be 'change for the better'; and this statement tends to vary in its definition from individual to individual. Large-scale social manipulations for change fall into the realms of professional party politics on the national and international scale. What is a 'change for the better' *here* is *there* a matter of furious debate, frequent exchanges of ill-feeling, and all too often war. The latter condition itself can hardly be regarded as a 'change for the better' in any but the most extreme cases. But like it or no we have to agree with Heraclitus when he said that nothing is permanent but change: evolution, cultural and/or physical, never stops.

We may not like what we see ahead, the possible routes for the

evolving Man, but we can only change them; we cannot isolate ourselves from them. Man, the human being in physical, intellectual, social, emotional and spiritual terms, is going to change. There is no way that this hard fact of existence can be avoided. We may dream of remaining more or less as we are, with more sophisticated technology perhaps and more rational systems of law and government. But if this dream has as its basis mankind remaining fundamentally the same as it is today then truly it is a dream.

Before we can approach that crucial point on the horizon in this investigation it is important to examine the dream and to dispel it.

Most science-fiction stories set in the centuries ahead tend to perpetuate the dream because it is much easier to communicate with people in our own society by setting the novel or short story in some recognisable variant of that society. For this reason I am going to take as an example the society which Larry Niven and Jerry Pournelle created for their joint work, *The Mote in God's Eye*.[4] (This is not to be a criticism of the book, which personally I found immensely enjoyable; this is simply an examination of one variant of the dream.)

By the year 3017, one thousand and thirty-nine years ahead of the time at which I am writing this chapter, Man is spread across the stars in a vast Empire and, like most empires, this one has troubles with dissidents. The opening pages concern themselves with a band of rebels being quelled by Imperial troops on a planet known as New Chicago.

One thousand and thirty-nine years in our past the Arabs were having even greater difficulty holding their empire together, losing Madrid to Leon that year (939). In fact, the whole future chronology seems to relate quite closely to the past two thousand years of European history. There are colonisations, coronations, empires, wars and even society crumbling back into the Dark Ages only to emerge triumphant again. Bringing the future properly and democratically up to date, the Emperor appears to be a constitutional sovereign inasmuch as he has his Viceroys dotted about the Galaxy; these in their turn appoint governors to the various planets. He has also an Imperial Parliament to which elected members may be sent from the various worlds, all of which have their own democratically elected assemblies.

There are many other variants of this dream: some see in tomorrow the historically 'inevitable' emergence of a communist Utopia, other see it as the territory of supercorporations where nations are but token institutions. Whatever the dream, it always has its roots firmly in the present or in the past. There seems no

other way of looking at the future constructively. Unfortunately the dream takes that which is already established and modifies it only marginally and usually superficially when placing it in a future context.

We tend to laugh at portrayals of the twentieth century seen through the eyes of the past. They seem ludicrous because so much has taken place in the interim which the previous writers have missed. For example, there is the anonymous book published in 1763 entitled *The Reign of George VI.*[5] In this the twentieth-century King of England is victorious at the end of the European Wars. This does sound vaguely like the stuff of prophecy until we realise that this King George is an idealised eighteenth-century-style monarch who leads his troops into battle on horseback with unsheathed sword. Ships of the line blaze away at frigates in set-piece naval battles and the most revolutionary weapon appears to be the fireship.

Of course, it can be argued that SF in the mould of *The Mote in God's Eye* incorporates the concept of great technological advancement (the Alderson Drive which gives Man the stars). In fact, a great deal of SF, including this major work, idealises the technological exploitation of scientific discovery much in the same way as *George VI* idealises the concept of kingship. Conflict arises not from the idealised subject matter but among the personalities involved with it.

Here we have the key to the dream: it lies in a kind of perfectionism. By this I mean the 'perfected' oppressive State which Orwell described in *Nineteen Eighty-four* and the 'perfected' Advertising Agency world, in which humans have the status of consumer units, in Pohl and Kornbluth's *The Space Merchants.*[6] In perfectionism, single aspects of present-day society dominate the future in the way their authors see them influencing the present.

History does not seem to operate like this, however. It quite obstinately refuses to be predictable, reading more like a catalogue of surprises than an even semi-logical progression of events. Most writers who set a work in the future do not expect their readers to regard it as a predictive statement. The best are often cautioning in their tone – not so much dreams as nightmares. Many, unfortunately, postulate a future intended as neither utopian nor anti-utopian but as arguably probable. The failing here is that few have an evolutionary perspective, even socially.

For example, the sophistication of political thought over the past millennium has been a major factor in the shaping of political systems and groupings in the world today. To

assume that there will be no innovations in this area is surely naïve.

So, when we are postulating a future for Man, we must postulate on the basis of what the major innovative changes are likely to be rather than on what aspects of life today are likely to dominate life tomorrow. The major innovative changes are those introduced by new and valid concepts – so how can we postulate, as these are presently unknown?

What I am going to do is speculate that changes will take place in areas where they are almost certain to occur, and areas, at that, which are crucial to the evolution of human beings both as social creatures and as a species. If these are in any way even near accurate then the Galaxy may very well be fairly well penetrated by our descendants in the year 3017, but by that time *Homo sapiens* will almost entirely have vanished.

Specifically, the area from which I see the evolutionary leap emerging is cybernetics: 'cybernetics' was defined by Norbert Wiener[7] as the science of control and communication in the animal and the machine. Essentially, the areas which will be involved in the transformation of Man are genetic engineering and intelligence simulation in machines. No one would be more surprised than myself if these proved to be the only areas of technology within which breakthroughs proved to have dramatic social consequences. I would suggest that we will see some startling steps in material science ('smart materials' programmed to alter physical properties and shape in various circumstances), data storage ('pocket'-sized libraries), and in learning technology (drugs which enhance both long-and short-term memory).

But, to return to cybernetics, I would say that it is here that the most obvious evolutionary impacts can and will be made. Control of genetic information is crucial where a new species is to be created to any preconceived design specifications. As I am concerned with the creation of a new species (or several thousand new species), a degree of sophistication which we do not yet possess in biological engineering is a prerequisite. But much more important than this is the actual willingness to use that sophistication on the DNA, the genetic code-stuff of human beings. This, after all, is the ultimate in eugenics.[8]

Eugenics raises a number of fairly major moral and political problems (as well as hackles). The very fact that these will have to be wrestled with means that, when mankind comes to use his genetic wizardry on himself, the moral and political climate will be changing accordingly. This illustrates that technological progress is

not isolated from social and political progress.

Perhaps there are those who doubt that the human race will be changed by eugenics, by a genetic policy. Is there a good reason why eugenics is inevitable? Well, perhaps it is not. I can imagine that, with societies run according to the low-scale alternative technologies advocated by some followers of the Club of Rome, humanity would be fairly safe from the horrors of the ravaged environment, the bomb and the 'terminal laboratory experiment'. Unfortunately, the economic changes which this type of society requires would in my opinion create traumas of a completely unacceptable level in politics, military circles, and the financial establishment. It would mean the end of the growth-oriented society. I do not believe that this is yet in sight.

To be basic about it, eugenics, unlike limited growth economics, does not affect the voter's bank balances adversely. People generally prefer to anguishedly clutch the brow rather than the wallet and most politicians tend to respond to this accordingly. Consequently I tend to think that we will see eugenic legislation in the field of human genetic engineering quite some time before deliberate attempts are made to profoundly change the growth orientation of society.

Apart from the fact that engineering eugenics could eradicate such things as sickle-cell anaemia, mongolism and spina bifida without resorting to restriction of the breeding of couples linked to these, or even sterilisation, there is the commercial aspect, which could contribute to the growth-society philosophy. 'Ensure your child's high IQ for three thousand dollars': specific highly prized characteristics could be enhanced on the genetic material.

Already there have been a number of experiments using the genetic matter of human beings; for example, the creation of hybrid man-plant organisms has been successfully accomplished. The really important step comes when we attempt to interfere not with the human body but with the mind. I believe that the day will come when we deliberately set about the process of endowing our progeny with the intelligence levels of geniuses simply so that they will be on a level with their peers. The general idea of brain enhancement will then be a commonplace.

Already there are drugs which combat the mental effects of senility by slowing them and in some cases even reversing them. It is a logical step from this to drugs which aid the brain's functions in other ways: memory, concentration, imagination, emotional control and so on. With this psychologically acceptable, the concept of 'plugging in' the brain to a computer becomes

palatable. We are then into the area of computer-aided intelligence.

But the computers themselves, by this point, will have moved on from the current generation of machines to a state of the art where the privacy of the individual will be seriously threatened. This is already apparent today. Grosch, the Cassandra figure of computing, has pointed out that, with the fourth generation of these machines emerging, we are threatened with 'invasion of privacy, domination of law processes by FBI type agencies'.[9] Rather gloomily, but realistically in this context, Grosch's Third Law states that 'things will get worse without limit'.

Indeed they will, and ironically the best defence against invasion of privacy will be access to your own high-performance computer. It will have to be one which can be isolated from the growing networks of computers and inaccessible to the various methods of electronic burglary. This may simply mean that all the data and operational programs which are relevant to you are restricted to your usage by some complex codes and passwords – rather like the electronic equivalent of a safety deposit box.

The machines themselves will be becoming much 'smarter'. This will be due to the increasingly efficient design of not so much the machines as of the software, the programs. Whether or not genuine artificial intelligence is created in this area, a certain amount of machine intelligence will be used. This will take the form of programs designed to mimic intelligent action in certain restricted situations.

Already computer programs are quite heavily employed in the business of designing other computer programs; it seems that the logical extension of this would be the machine system which was capable not only of designing itself but a more efficient version of itself, a 'smarter' version. Obviously, if this new machine is built it will be even more capable of this feat than its predecessor ... and we find ourselves with an exponential rise in the performance characteristics of the machines.[10]

There is a very cogent extension of this theme, that of the self-reproducing machine. This concept was worked out in detail by John von Neumann, father of the present-day computer, and has been called the von Neumann machine by Freeman Dyson in honour of the great man. In his book *Disturbing the Universe* Dyson points out that, once functioning, von Neumann machines would reproduce at around the rate of one per year – and the potential for mankind would be staggering. The machines would be capable of doubling their numbers annually and within a single

generation there could be one for every working person on the planet.

Now, as a von Neumann machine is theoretically capable of doing anything which any other machine can do, this could free mankind from the need to labour for the material necessities of life and for virtually all machine-produced luxury goods. There is a further SETI/CETI application of this technology which we shall come to in Chapter 8.

Obviously such machines would operate off the Earth, or pollution would be rampant. Thus most industry would move from the face of the planet to that energy-rich environment where there are no known lifeforms to be killed off by industrial waste: outer space.

Today there already exist robots whose individual 'earnings' could each support several families in the average lifestyle of Western society. These are limited drudges slaving away in factories, but their descendants will be much more sophisticated and capable of considerably higher 'earnings'. The result will bring problems. The poverty gap between rich and poor both as individuals and nations would eventually disappear and political systems, such socio-economic systems as communism and capitalism, would go down kicking furiously giving way to an extreme political condition – likely to be either basically totalitarian as Grosch envisages, or some form of individual-oriented structure like functional anarchism. If man is proved capable of acting individually morally and altruistically in most situations the latter may prove possible. Sadly, in the light of our activities the former appears to be the more likely prospect.

Machines as complex as a von Neumann machine would be much 'smarter' than any present-day computer. Furthermore, being able to enhance elements in their own design, they would evolve rapidly from generation to generation.

This does not mean that these machines will eventually turn into intelligent beings. They will still be restricted inasmuch as the data base upon which they will be operating will, we assume, be that of the original machine. Within that restricted system they will become superior to the capabilities of Man: becoming superior to Man himself would mean that the system would have to have as its data base the information present in the brain of a new-born child plus a design programme to enhance the design of the system as a whole.

But the debate about intelligent and ultra-intelligent machines has been rolling along for decades and has a long way to go yet. The

mathematician I. J. Good, a friend of the late John von Neumann, has been convinced of their inevitable appearance for over a quarter of a century. Part of his argument is that contrary to widespread belief there is no way of arriving at valid conclusions or working solutions to problems without the use of logic. Hunches and inspirations are not, in this view, just lucky guesswork but are inductive reasoning taking place in catastrophic and/or subconscious leaps. So if all thought is a form of logic, and intelligence is based on thought, then computers, being highly logical by nature, should be ultimately capable of intelligence.

Most computer people to whom I have talked about this matter, including those whose work involves looking at where computer design is likely to go, regard this as totally impossible. Being an SF writer I tend to dismiss their highly qualified opinions with my unqualified and mindlessly confident one that superior artificial intelligence is feasible. Where I do to some extent agree with the computer specialists is that I do not see the 'god-like machine' arising from this area. Not on its own, anyway.

We are at the position where there is a direct interface between the human brain and the computer. I would like to predict that the feedback from this combination will be so staggering that more research will go into the enhancing of this relationship than anything related to artificial intelligence.[11] This would bring about a position where the minds of geniuses by the million are being enhanced, artificially boosted by super-computers capable of handling masses of information and flickering it selectively into those brains as it is required. No need for libraries; all the information relevant to a subject is there and being referred to as the genius simply thinks about it. In this situation one psychopath might dream up overnight half a dozen feasible plans to destroy civilisation and wipe out the human race several times over.

Our generation of geniuses will realise this long before the possibility ever becomes real. There will have to be two basic safeguards. Firstly, all machines will have to be limited; none will be able to assist such thinking and, once it has identified a psychopathic thought pattern, a machine will automatically alert Grosch's FBI type agency, Orwell's Thought Police. The second aspect of safety will be eugenic. Man will be made biologically incapable of killing his fellow man in almost every situation. This limiter may be written into the DNA itself, if possible. The release mechanisms which would allow such an action will be contained jointly in Man and in his symbiotic mechanical aids.

With the emergence of the man-machine hybrid already perform-

ing surgery on the nature of human nature we see the curtain falling on *Homo sapiens*.

Whether or not the 'Hybrids', as I shall call them, wish to maintain a human form they will almost certainly go about the process of farming better minds for themselves. The brains will be grown as clones from originally human genetic material. They will probably be designed around the Hybrid needs and, at present, it is impossible to say what these are. From our own point in time we might speculate that the surface area of the neo-cortex might be increased (folded more complexly) and that the newer parts of the brain be linked with the older parts in a fashion whereby the newer part was always in control of the relationship.

Alternatively, the actual organic material – nerve tissue, in other words – may be forsaken for something totally different, silicon crystal perhaps. Instead of designing a brain in this material the relationships between the various brain cells which are expressed through the synaptic connections would be copied exactly with the much smaller interstitials between the crystals taking the place of the synapses.

What would such Hybrids be like? To begin with, they would be virtually immortal. Their intelligence levels would be meaningless, in real terms, to us. They would be telepathic to all intents and purposes as they would be able not only to transmit thoughts to one another by electromagnetic impulses but to conjoin into 'think tanks' the likes of which it is pointless to speculate upon.[12] They would not be limited to our five senses; they would be able to smell colours, taste heat, feel aromas and so on in environments where *Homo sapiens* would have blundered about swathed in protective clothing. Their emotional lives would have a potential richness beyond all imagining.

What would they look like? Not like us. And who can really say? Perhaps like great crystalline blocks containing a million minds or more and speeding out towards the star clouds. Perhaps they would have one or more human-type forms which they could occupy by remote control if they so desired.

And, finally , when?

Guess hazarding is always risky in the prediction business. It might be possible to produce the first Hybrid within the next one hundred years, perhaps a good deal sooner. On the other hand my predictions could prove as useless a guide to the future* as any other exercise in speculation based on personal belief.

But, if I am right and if our encounter is with creatures who are representatives of what amounts to our future not a century ahead but some *two hundred centuries hence* ...

* See Appendix 4.

6 – Saucers and Dishes

There are many books which act as excellent outlines to CETI's history and current thinking.[1] It is not my intention to give a detailed resumé of what you can find in these texts but it would be remiss of me if I did not include a rough sketch of what has taken place in the field during the past three decades.

Most people seem to be under the impression that there has been little, if any, serious scientific work done in the entire area. This is probably more so the case for those who live in English-speaking countries; they will be well acquainted with the steady stream of derision which has poured from the establishment – both scientific and bureaucratic – on the topic of UFOs. However, UFOs and CETI should not be confused. The areas of study have quite distinct roots.

Reports of strange 'foo-fighters' were made mostly by military pilots in the second half of the nineteen-forties. These became a craze or cult – call it what you will. There has been a lot of 'evidence' but none that leads to any conclusion universally accepted regarding the nature of these weird happenings.

There is no connection between that and the emergence of the idea of CETI. Public enthusiasm for UFOs, which frequently verged on the hysterical during the 'fifties, tended to make scientists keep their mouths shut about private speculations on intelligent life existing elsewhere.

CETI is a dangerous area to tread around, which is one of the reasons that it attracts certain types of people. Furthermore, there are more hazards than simply being tarred with the 'UFO-freak' brush. Nature and colleagues alike can make the CETI-interested scientist feel idiotic and the object of laughter from others. There is an old Arabic saying: 'The dogs bark but still the caravan moves on.' This is very much the attitude which the scientist has to adopt in such cases.

As I said above, speculation on the subject by scientists was very low-key during the early and mid-nineteen-fifties. If anyone talked about CETI they did so in private to equally interested friends. One such was a physicist by the name of Giuseppe Cocconi, who had discussed the possibilities with Philip Morrison, another physicist. Excited about the possibilies of ETI broadcasting radio messages, Cocconi wrote a letter to Dr (later Sir) Bernard Lovell on 29 June

1959. He presented in this his case for utilising the new radio telescope at Jodrell Bank in a search for radio evidence of ETI. Lovell, the observatory's director, replied briefly and disappointingly, according to Cocconi. In fact, Lovell found the suggestion 'frivolous'.

Not to be deterred, Cocconi and Morrison wrote a paper in August that year for *Nature*, Britain's august scientific journal. In this they speculated that radio broadcasts might be found in the region of the hydrogen emission line in the radio spectrum at 21cm (1420 MHz) which might act as an electromagnetic landmark for such activities.

One of the world's most eminent scientific publications, *Nature* was an excellent choice. In the past it had presented a good number of equally sensational and imaginative concepts within its pages. This one was to prove no exception. The proposal appeared in the issue for 19 September that year.

At last it was possible to talk openly and respectably about the subject, if at some distance from the ordinary public and safe from the ridicule of the press. One of the startling facts to emerge was that a search along the lines suggested by the two physicists had been planned in virtual secrecy at the National Radio Astronomy Observatory at West Bank, West Virginia.

Frank Drake, an astronomer working there and a graduate of Cornell, had proposed a similar scheme to Lloyd Berkner, the Acting Director of the observatory. The older man expected that such a scheme would be scoffed at but he evidently believed this particular caravan would move on because he encouraged Drake. He even went so far as to bring the subject of Drake's proposals up with the man who was to be appointed as the full time head of the observatory, Otto Struve.

The project was initiated in April 1959. The following month Struve took over the full-time job of director and was largely responsible for running the project. Drake called it Project Ozma after the Princess Ozma of the exotic land of Oz conjured up for children by Lyman Frank Baum.

In the spring of 1960 the search began. There was a great deal of mixed feelings within the scientific community, and no one was particularly surprised when the two stars which had been repeatedly scanned, Tau Ceti at almost twelve light years distance, and 61 Cygni at just over eleven, rendered no significant results.

There came the expected hoots of derision and noisy raspberry blowing but nevertheless CETI had arrived. Even Sir Bernard

Lovell mellowed. By 1962 he felt sympathetic to 'an idea which only a few years ago would have seemed rather far-fetched'.

There are three possible areas of search for CETI (or SETI –search for extraterrestrial intelligence).

The first is for astronomers to make a search for radio signals. I put this first because it is the one receiving the most attention by members of the scientific community, not because I believe it to be the best (I most definitely do not). There are various different types of communication of this sort which we may intercept. We may tune in to a beacon broadcasting generally into the Galaxy or specifically at us. We may also pick up a message being transmitted between two ETIs already in mutual communication. Lastly, we may 'overhear' the domestic radio traffic of another planet much in the same way that they would be able to 'overhear' our own. Remember that, by the year 2000 AD, mankind's electromagnetic squawking will be 'audible' over seventy light years in any direction in which you care to point, a volume of some one and a half million cubic light years. And, if we can hear them, they can hear us.

Radio signalling should really be termed EMG (electromagnetic) signalling. There is a good deal of discussion concerning other areas within the electromagnetic spectrum which might be useful for interstellar contact. Lasers have been proposed; not merely optical lasers either. There has been discussion on the use of X-rays, gamma rays, neutrinos, etc. The basic beliefs on strategy, however, remain the same: interaction between ETIs in different stellar systems can take place only by means of signals.

The two other avenues open to SETI are not given substantial credence by most workers in the field. This is probably because they verge on the sensational rather than because of any arguments which have been aligned against them.

The most sensational of these is, of course, the possibility of an ETI presence here on Earth at the moment or at some time in the past. As far as the present is concerned, UFOs are generally what the public think of when CETI is mentioned, spacecraft crewed by verdant antennaed dwarfs. Close on the diminutive heels of these cute little characters come the ancient and semi-divine astronauts. How sad it is that public thought on the subject of CETI is limited to these two.

No one knows, or is sane and admits to knowing, of a way to prove what all UFOs really are. For this reason, if none other, we should not dismiss completely out of hand the possibility that there may be an ETI explanation for some reports. There may also be

psychical, religious, occult, or even perfectly natural terrestrial explanations. We cannot prove anything concerning UFOs – that is, truly *unidentified* flying objects.

What we can do is take a look at the hypothesis that they really are ETI spacecraft and see how well it stands up. From reports we can estimate how rapidly they accelerate and how they move. We know of no propulsion system capable of doing this. A direct consequence of the movement pattern entails *g* forces which would cripple or kill the average human being travelling inside and tear apart the structures of the hardiest flying machines which we have built. They are not built or propelled according to the principles which we apply to spacecraft and they are not peopled by beings physically like us unless there is some field force, currently inconceivable to us, which effectively isolates the crew from the crushing acceleration.

All right, for the sake of argument let us accept that some few are spaceships. What does this tell us about the Universe, particularly the Galaxy in which we lie? An American physicist, Hong-Yee Chiu, has worked out that the mass required to build even a small number of UFOs arriving each year at every star in the Galaxy means that by now some two billion stars, or about one percent of the Galaxy as a whole, would have been mined.[2] The problem is that, even if this massive industrial operation is under way, we have no way of detecting it. Perhaps stars which are being 'mined' show spectral anomalies, but how are we to distinguish the spectral anomalies which are artificially created from those which are created by natural processes of which we are not yet aware? Even if UFOs are being mass-produced like spacefaring widgets, we cannot say so from our present investigations.

Placing the UFO-spaceship hypothesis in the 'things we have yet to understand category' does no good whatsoever. This is the *ad hoc* hypothesis category where we again find the psychic, the religious and the occult (UFOlogists might disagree).

Back to square one. In time all *ad hoc* hypotheses may become subject to proper scientific scrutiny, but that does not help us here and now.

So what about the ancient astronauts? The works of Erich von Däniken do not comprise my favourite reading but there is no point in my criticising his works as the job has been done expertly by Ronald Story. Story's surgically incisive investigation, *The Space-Gods Revealed*, dismembers von Däniken's theses with a flourish which I imagine has not been seen since Rome banned gladitorial combat from the Coliseum.

The potential investigator of SETI-archaeology, searching the past for evidence of ETI visitation, must be very careful. He is liable to be tarred with the von Däniken brush. For some time to come those who are interested in this topic may well adopt a low profile, as did CETI during the 'fifties.

An artefact which evidently was the product of an advanced technology and was discovered in an archaeological dig among material from a time when, to our knowledge, no such technology could have existed would open the possibility that ETIs visited Earth in the past. It would also open the possibility that there was once a very advanced terrestrial civilisation of which we have no record. Several such artefacts might render a better picture of the technological capabilities of the originators, but a good deal of material would have to be amassed before either the ETI or the purely terrestrial model was ruled out.[3] A richer approach should be the search for that which is of indisputable origin. A large installation upon the Earth now covered by millennia of surface activity might be worth looking for. A databank left deliberately for us would be even more interesting. The problem is, where might the departing ETI decide to place the databank?

We know that if they were here and did leave one, they intended that it should be found. Thus we can assume that they would have taken steps to make sure that in a given set of circumstances we would find it. Following from this we can say that there are three possibilities relating to its discovery.

First of all, the databank may have been intended for us to have access to at an earlier period in our history. If so, we can imagine that the given set of circumstances changed in a manner unforeseen by the ETIs after their departure. This could have been an earthquake, volcanic eruption or other natural catastrophe.

Secondly, we may not have the ability to appreciate the significance of the set of circumstances or recognise the databank for what it is. If this is a matter of an evolutionary quirk it might be an extension of the first possibility, in that either they anticipated another animal would evolve mentally faster than our ancestors did or that we evolved in a different manner to that which they expected.

The last possibility is that before now (and perhaps not even now) the set of circumstances has not been complete. For example, a standard degree of technology may be a prerequisite for our appreciation of the databank indicator. SETI-archaeology would, naturally, be another prerequisite in many such cases, although not all.

Only a civilisation with knowledge of radioactivity would appreciate the singularity of the natural atomic reactor in French Equatorial Africa.[4] A suitably insulated databank might be placed inside this with the knowledge that only a human society with a fairly highly developed scientific capability would investigate this phenomenon.

If the departing extraterrestrials were interested particularly in those members of our society who would be pursuing SETI they might have chosen an unmistakably extraterrestrial reference point on the surface of the Earth. The centre of South Africa's Vredevoort Ring meteorite impact crater could be a candidate, or perhaps one of Mauritania's larger Richat craters, should these prove to be meteoritic in origin.

In the event of our morality being a particularly crucial characteristic which they would have wished to include in their key set of circumstances things grow much more difficult. They might have left the databank concealed in such a way that only a civilisation which had passed through our present nuclear adolescence would discover it. This might entail placing it off the Earth, a possibility which we will explore in a moment.

They might have wished to leave it to a society which is conservation-oriented, non-xenophobic and interested in communication with other AMLs. Such a race would be ideal to move among the stars doing minimum damage to the Galactic environment or to the beings which inhabit it. To accomplish this, the databank should ideally be embedded in an aspect of our environment threatened by our destructive impulses, ravaging greed and the urge to eliminate any other AML. Could the databank be genetically buried in the enormous complexities of the cetacean brain, say? Could this even be the reason why these animals have such large and complex brains? Are they in fact aquatic librarians with enormous storehouses of knowledge locked away within the recesses of their non-human minds?[5]

The final prospect of SETI is that tangible, irrefutable evidence lies beyond the Earth but within the Solar System,[6] a possibility explored in the finest of all English-language SF movies *2001: A Space Odyssey*. Artefacts on the Moon would not be subject to the ravages of surface activity on Earth. Even simple oxidation would be absent and, in the case of a buried object, smaller meteor impacts would be harmless: the electromagnetic sunstorm which the lunar surface is subjected to would be at a safe distance and the temperature flux would be suitably low.

Where should we look?

Again, the most prominent indicator of an extralunar connection might be a useful starting point. In this case it proves to be the quite startling Mare Orientale, a vast complex crater structure unlike anything else on the Moon. It is further significant in that it cannot be appreciated when viewed from Earth as it is always seen edge on. Perhaps some time in the opening decades of the next century a team of selenologists might uncover something rather unexpected right in the centre of this remarkable feature.

Alternatively, the databank may have been placed in an orbit about some body in the Solar System. Perhaps it follows a cometary path which brings it close to the orbit of Earth every few decades. It may have visited us during the Second World War, perhaps, and we were too preoccupied to heed its attempts at communication. Such a databank would probably stay closed down for most of its orbit, powering up only as it approached and monitored us and perhaps attempted to make its presence known. On the swing away from the Sun it would close down, performing as few maintenance activities as were needed through the preserving cold until it again approached the Sun and Earth briefly. To ensure that the other planets did not distort its orbit too greatly the databank would possibly be placed in an orbit inclined at ninety degrees to the plane of the ecliptic, the great invisible disc with the Sun at its centre and the orbits of most planets inscribed upon its surface.

This leads us straight on to our third possibility, the proposal that there may prove to be a probe from another star system orbiting our own Sun and perhaps even in orbit around the Earth. This was first put forward as an idea by Professor Ronald N Bracewell of Stanford University in an article which he wrote for *Nature* in 1960.[7]

We send out numerous robot explorers to the planets, so it seems fairly reasonable to suppose that another star system which evolved an advanced form of mental life with a desire to reach across interstellar space might dispatch a similar device towards us. If it did not simply fly though our Solar System but took up residence here there is a possibility that we might make contact with it. Even if it has been in space somewhere fairly nearby for hundreds or perhaps even thousands of years it might still be functional. Wear and tear from the environment out there is in some ways rougher, due to radiation exposure and temperature extremes, than might be expected on Earth. The compensation comes in the form of missing Earth's atmospheric effects, such as wind, rain, oxidation and other corrosive activities.

This is quite exciting because, even if the spaceprobe is inactive, it

is at least something possibly resident in our system. It gives us the possibility of something substantial and fairly permanent to search for instead of the fleeting radio wave. One probe discovered would probably yield more information far more rapidly than an intercepted radio signal, particularly at first and certainly if the radio signal is not a beacon but either domestic radio traffic or a communication from one ETI to another.

The general criticisms of the spaceprobe hypothesis are founded on efficiency. First of all, it is a very expensive method of going about CETI. The costs involved are enormous in comparison with the transmission of radio information. An ETI employing spaceprobes for CETI purposes similar to our robot explorers would probably have a very different appreciation of priorities involved in the subject than most CETI thinkers here on Earth. Cost would not be one of the prime considerations.

Another criticism of the spaceprobe hypothesis rests on the distances involved in flights between two ETIs. Here there is the problem that, by the time the spacecraft reaches its target star system, the home system ETI may have passed beyond its lifespan. Considering that interstellar flights may entail coasting through space for decades, centuries or even millennia, this is possible.

Alternatively, an ETI which realised that it was soon to perish might send out a number of such spaceprobes to likely nearby star systems. These would effectively be time-capsules or databanks which might indicate to an emerging intelligence the problems which lay ahead, the strategies which the ETI employed and why it ultimately failed.

The model of the development of Advanced Mental Life in the Galaxy which makes it somewhat more fruitful to search for such probes is the one where there are very few active ETI intelligences in the Galaxy at any given time. This means that the lifetime of the ETI once it reaches the appropriate level is all important. In this sense the ETI has to be regarded not merely as a being or group of beings but a condition which involves sentience with a long developmental history in terms of knowledge and capabilities. In Man this is best expressed in terms of civilisations. Obviously the knowledge and capabilities of a civilisation greatly exceed those of any individual within it. Accordingly we should require a similar level of complexity in the ETI.

How long an AML remains at the level of being able to indulge in CETI and wishing to do so is a critical factor in assessing the number of such AMLs. This number determines the average distance separating them and thus has a direct bearing on any

exchange of signals. If there are many such ETIs, we can expect there to be a fairly active radio discourse taking place; but, if there are few, there may be very little if indeed any communication of this sort at all.

In the event of there being few CETI-oriented lifeforms, they may not survive sufficiently long to set up a dialogue across the vast reaches of interstellar space. Bracewell has estimated that, should we receive a signal from an ETI some one and a quarter thousand light years away our reply should reach it, if it were sent immediately, just at the point when that 'civilisation' was either perishing or moving out of its CETI phase. If this is common, some ETIs may well place robot databanks in other likely star systems. However, it may prove to be a better and cheaper strategy to place automatic addressable beacons marking the passing on of such mental lifeforms broadcasting from their home system.

The construction of spaceprobes purely for the purposes of seeking out and establishing contact with ETIs is an approach which we humans would be most unlikely to adopt. This does not mean to say that an ETI would eschew it but it does mean that psychologically we are likely to be biased against investigating the chances of such probes being resident in the Solar System.

An extension of this is the starship peopled with ETIs entering the Solar System. This is a circumstance which has been given a great deal of coverage by science-fiction writers but virtually none by serious students of CETI. Yet, today, we are beginning seriously to consider the possibilities of interstellar flight and its problems.[8]

There is no way of logically demonstrating that we are more likely to hear a radio signal than be visited by a spaceship. The choices are based on what we know of the technology of the one AML with which we are familiar – ourselves. The drawback here lies in the fact that we have a disquieting historical perspective to bear in mind. If the scientists of a century past had been avid CETI fanatics they would have searched their known Universe vainly for signs of intelligent life elsewhere. They would not have considered radio because they knew nothing of it. Philip Morrison points out that we may be in the same position and that the ideal method of interstellar communication is by 'Q' waves, as yet undiscovered by terrestrial science.

This has not impaired the intense discussions on the use of radio for CETI. Indeed, over the past two decades, this facet of the subject has dominated the whole to such an extent that it has become something of an establishment attitude. It is now those who do not subscribe to the interstellar radio-signal

hypothesis who must smile as the custard pies arrive.

Perhaps this is only fair, as the radio buffs have been squarely buffeted with these metaphorical missiles for some time now, and quite soundly on certain occasions. The Soviet Academy of Sciences, in particular, has had a rather unfortunate history in this respect. On three occasions they have been made to look slightly foolish. The first was the affair of CTA-102, when it was supposed that the Russians had discovered a super-civilisation but this proved not to be the case. The radio signal which they were studying proved to be a natural radio source.

CTA-102 (and another source, CTA-21) had been the subject of some conjecture by the Soviet researcher Nikolai Kardashev. In 1964 he had postulated that these might be distant ETI civilisations because their radio spectra appeared quite singular in respect to other known radio sources. The following year came the sensational discovery that CTA-102 fluctuated smoothly in 100-day cycles. Although the scientists were interested it was *Tass*, the news agency, which decided that this was indeed an artificial beacon transmitting across the Galaxy. Pressed by newsmen boggle-eyed at the prospect of handling the story of the century, the embarrassed scientists admitted that, although it was premature to say anything firm, it was at least possible that this could be another civilisation.

The custard pie came in the form of an announcement shortly afterwards that CTA-102 had proved to be one of the recently discovered quasars.

More recently, in October 1973, the Radio Institute at Gorki released a communiqué to the effect that it had picked up signals of ETI origin arriving in bursts of between two and ten minutes' duration. Interestingly enough, they seemed to be coming from somewhere within our own Solar System. There was some backpedalling after further investigation revealed that what had been received was capable of being explained by an artificial satellite in Earth orbit.

The most spectacular suggestion had not to do with radio at all but came from Academician Shklovskii in his book *Universe, Life, Mind*[9] published in Russia for the fifth anniversary of spaceflight. Shklovskii put forward the startling proposition that Phobos, the inner of Mars' two moons, was in fact a gigantic artificial satellite. Sadly, photographs of Phobos now indicate that this is very unlikely, and the information upon which the Soviet scientist based his calculations is now regarded as being suspect.

How then does one avoid the custard pies?

The British example gives us some indication. In December 1967

some very peculiar radio signals were detected by a group of Cambridge astronomers. The signals were very rapid and startlingly regular, just what one might have expected from an ETI beacon. While they were being investigated they were titled LGMs, an abbreviation for Little Green Men. Jocelyn Bell, a research student working at the Cavendish Laboratory with Professor Anthony Hewish, was the first person to come across this phenomenon. After several months of very quiet investigation, during which the possibility that they were looking at evidence of intelligent life far out in space was not easy to dismiss, they came to a conclusion. By this time three other such radio sources had been charted, and close scrutiny showed they demonstrated the basic characteristics of stars. They were in fact natural objects. Today they are generally accepted as rapidly spinning neutron stars: pulsars.

Obviously radio astronomy is a very exciting field to work in. Naturally some of those involved in it tend to frown when they hear talk of their observatories being used for CETI purposes. Their work is so demanding of observatory time, and there is already so little of that available, that they grudge spending it on what they regard as frivolous activity. In a climate such as this it is not surprising that the discoverers of pulsars kept their heads well down for a few months before announcing their incredible find early in 1968.

The search continues. International conferences are now held frequently on the subject. Highly respected scientists the world over are involved in the debates. Perhaps most significantly of all, the tenor of the debates themselves has changed greatly over the past two decades from the theoretical to the practical. It has gone from the basis of trying to make the whole subject appear reasonable and therefore interesting to scientists in general to the examination of engineering considerations entailed in the optimum instruments designed for the purpose.

Again it is in the area of radio communication that most work is being done, and is intended to be done. Since Frank Drake's original Project Ozma there have been Ozma II and a number of other searches of the radio sky. To date, none of these has yielded a significant result. Nevertheless, in virtually every radio observatory in the world today someone has done some hopeful listening for signs of ETI activity.

The Russians are interested in the possibility that there is a high amount of interstellar radio traffic in the vicinity of the Galactic core and are concentrating a good deal of effort on examination of

the core regions' characteristics. The giant RATAN 600 instrument used by the Shternberg Institute in the Northern Caucasus is employed in this programme, which aims to scan the sky on as great a range of frequencies as possible. Hopefully a satellite capable of furthering the effectiveness of the Soviet-wide SETI radio-telescope network will be employed.

Kardashev seems at present to be seeking out either a Dyson shell[10] or other evidence of one of his own super-civilisations. These are approximately: Level One, capable of controlling the energy resources of a planet (roughly ourselves); Level Two, capable of utilising the energies of an entire star system (reducing most of the planets to rubble which orbits the star to form an energy-absorbing shell, and as suggested by Freeman Dyson); Level Three, which uses the energies of a complete galaxy.

NASA, too, is contemplating some exciting developments in the field of SETI. Cyclops is perhaps the most widely discussed system. It consists of more than a thousand steerable radio telescopes each with an antenna more than a hundred metres across. The result would be the equivalent of a single dish well over five kilometres in diameter. The whole system would be integrated and operated by computers allowing it to act virtually automatically. The same computer complex would apply a variety of enhancement procedures to the incoming signals to pick out salient information from the background noise.

There is also an orbital radio telescope under discussion in the USA. This would be a spherical construction assembled in sections brought up by the Space Shuttle. Shielded at all times from the intense radio interference from Earth the antenna would be able to scan the entire heavens in its sweep around the sky. It is proposed to place it in one of the libration points in the orbit of the Moon around the Earth in such a way that it, the Moon and the Earth would form the points of an equilateral triangle – each equidistant from the other.

The most ambitious programme is to set up a Cyclops array on the far side of the Moon. This would be fantastically expensive both to build and to support but it would be entirely shielded from any terrestrial interference by the whole bulk of the Moon.

The trouble is finance.

At the time of writing NASA is still fighting for funds to initiate a reasonable basic SETI programme. There is a little irony in the situation, which relates to the amount of cash they believe they need. The twenty million dollars, spread as two million a year over ten years, is roughly the amount which the film director Steven

Spielberg spent on his SF CETI movie *Close Encounters of the Third Kind*. Furthermore, at the time of writing, Spielberg has decided *Encounters II* should have some scenes shot on location and is so sure of his budget that he has booked Shuttle time to do filming in space!

Well, listening is fine, but how can you be sure that there are any signals to hear? How do you know that everyone is not simply adopting the same strategy of merely listening with no attempts at transmission? Well there is one way to be sure. Send out a signal yourself, and you can at least be certain that *that* one is being propagated out across the Universe – and if there is at least one zinging out across the void how many more might not there be of ETI origin?

Today such a little message is on its way from planet Earth to M13, a cluster of stars so distant that the signal will not arrive for some 24,000 years. It was broadcast from the 300m radio bowl at Arecibo in Puerto Rico and is made up of 1679 digits. The digits are a kind of dot-dash system like Morse code except that, unlike Morse, the message is not made up of letters but is in effect one gigantic word. The word is translated by straightforward arithmetic. There is only one way to factor the number 1679; that is to say, there are only two numbers which when multiplied together will give 1679 as a product: these are 23 and 73.

It is possible, therefore, to build up a picture from the dots either 23 by 73 or 73 by 23. The latter produces a meaningless jumble but the former results in a coherent dot-picture which the M13ians can then attempt to make sense of for some considerable time. It contains pictorial information about our Solar System, ourselves, and the broacasting instrument (which seems to be pointing upside down in the general direction of our feet, a fact that might lead the M13ians to deduce that we bounce around on our heads).

We sent it out in 1974 and may thus hope for a reply in the region of 50,000 AD. I would not recommend hanging around specially for this occasion as you are liable to be disappointed (and after all those millennia too!) The big let-down results from the fact that the signal will be difficult to snatch. It is only three minutes or so long and is being carried on a wavelength which has no particular significance for SETI (12.6cm was the radar wavelength the instrument was calibrated for at that particular moment).

Many scientists regard radio investigation of the heavens as the 'uniquely rational way' of going about CETI. This was originally the insight which Cocconi and Morrison found in the hydrogen

radio-emission wavelength. Since then there has been criticism of that wavelength and others have been put forward, notably the span between the hydroxyl wavelength at 18cm and that of hydrogen (21cm). This has been romantically christened the 'water hole'.[11]

The problem with this rational way is not a matter of whether there are signals presently sweeping past and through us. The problem with passive radio listening lies in the thought process, the very human thought process upon which it is based.

7 – Past Contact and the Moving Caravan

A few years ago Duncan Lunan, one of Scotland's few CETI theorists, put forward the thesis that there might be a spaceprobe, similar to the Bracewell type, in orbit about the Earth. What happened then is quite enlightening regarding the way in which various sections of the community reacted to his announcement.

If we wish to understand well how various members of the community are likely to react to the actual encounter should it occur sometime during the coming years or decades we should do more than speculate on the nature of the ETI. We should try to examine some of the attitudes of the throwers of the custard pies.

These are often individuals in positions of respect and responsibility. Their response to encounter could be of vital importance. Consequently I have invited Duncan Lunan to detail in this chapter some chronicles of his content and discontent arising from the publication of his spaceprobe hypothesis. He has also contributed his opinions on the likelihood of SETI archaeology proving a rewarding course for investigation.

Ironically, those scientists who criticised his previous hypothesis did not challenge it on scientific grounds but on the basis of its philosophical naïvety. They should have been told that this man's training was not principally in science, as was theirs, but in philosophy.

Between 1967 and 1972 I chaired a series of discussions on interstellar travel and communication at ASTRA, the Association in Scotland to Research into Astronautics.* Our ideas were eventually published under the title *Man and the Stars*[1] (*Interstellar Contact* in the USA) and included a full statement of my own 'Epsilon Boötis' interpretation of radio echo effects in the 1920s, which, Professor Bracewell at Stanford University had suggested, might have been an attempt at communication by a spaceprobe from another civilisation. The key parts of that hypothesis had already been published by the British Interplanetary Society and received worldwide publicity – much of it, unfortunately, sensational and inaccurate.

* At that time the initials stood for Association in Scotland for Technology and Research in Astronautics. The name was changed for legal reasons at the end of 1976.

For the record, the outcome was that the radio echo effect was traced with virtual certainty to the orbit of the Moon; to one, if not both, of the 'Trojan' or 'Equilateral' points where James Strong of the BIS had suggested a 'Bracewell probe' might be found. However Epsilon Boötis, the star I had suggested as the origin of the hypothetical probe, proved to be twice as far away as most catalogues stated: it was too massive and therefore too short-lived to have sustained intelligent life on any planets. In any case, when more accurate records from the 1920s were unearthed, several of my crucial star map interpretations were proved invalid. As to whether a 'Bracewell probe' did or does exist in the orbit of the Moon – no experimental search was made and to my mind the question remains unanswered. A hypothetical natural explanation for the echo effect was advanced by A. T. Lawton and S. J. Newton[2], but I find it unconvincing.

The reaction of the world to those developments was both interesting and instructive. On the popular level, to put in bluntly, nobody wanted to know that Epsilon Boötis had been ruled out. Although the facts about the star and against my interpretation were known by the beginning of 1974, this chapter will be only the second time that the news has appeared in print. Like C. J. Jung and I. S. Shklovskii before me, on UFOs and the moons of Mars respectively, I find that the 'Lunan/Epsilon Boötis story' now leads a life of its own and is cited repeatedly by speculative writers to support ideas of their own. At least three such authors are currently in print with such claims *despite* having checked with me and having been told Epsilon Boötis was out. Many of the successful UFO hoaxes in the literature persist likewise despite efforts by their perpetrators to 'come clean'. Indeed, the discovery that the public and the media *want* contact situations to be true comes as no surprise: Jung[3] and Christopher Evans, in his excellent *Cults of Unreason*,[4] have explored the manifestations of that need, and more evidence of it will be given below.

The reaction from the scientific world was more revealing. First publication of the hypothesis had aroused little public comment, and what little hostile reaction there was privately was in response to inaccurate press reports rather than to my own paper. Most of the criticism concentrated on the impropriety of attempting to translate the 1920s signals, without prior proof that an extra-terrestrial probe existed; yet nobody was prepared to conduct an active search. The precise wording of three such refusals will be given below. Reaction to the publication of the Lawton/Newton hypothesis can be described only as unalloyed relief. 'Lunan's

Theory "Junked",' declared a headline in the US journal *Astronomy*, without troubling to see if I accepted the refutation of the probe's existence. In fact I do not; but the authors of a recent book on CETI roundly declare 'Lunan now openly accepts Lawton's findings', an outright fabrication which they made no attempt to verify. Indeed, only two authors on this level have ever asked me whether I accept my supposed 'junking', and neither has quoted me as yet. The acceptance/rejection patterns, in the media and the world of science, are almost perfect mirror images; if the former reflects a desire for contact hypotheses to be true, there may be grounds for suspecting the objectivity of the latter. Stronger arguments are certainly needed to support that statement, and will be advanced below.

But the reaction from the general public, worldwide, was something else again; just as Carl Sagan has described the Pioneer 10 plaque as a 'message to Earth' as much as to any future extraterrestrial culture.[5] The spaceprobe hypothesis received press and/or radio/TV coverage on every continent on Earth except India (to my knowledge) and in most of the individual nations of Europe, the Americas, Africa and the USSR. To date the publicity and the continuing sale of *Man and the Stars* have brought in about 2,000 letters from all over the world, from people of all walks of life and standards of intellectual attainment, mostly asking for information. Now comes the rub: not one of those letter-writers was hostile to the idea of contact with other intelligence and not a single one was afraid of it. Many of the letters were foolish, some comically so, some sadly; but no one's folly or sanity made them ask me to leave well alone. Even those who doubted the spaceprobe's existence were at pains to say that they favoured CETI research in general, but there seemed to be far more who wanted reassurance (I use the word advisedly) that it could be true.

That particular outcome of the spaceprobe affair seems to me so important, as an impromptu opinion poll, that it deserves emphasis. It is, for example, a commonplace of the UFO movement that the world's governments suppress contact information 'in order to prevent a panic'. Well, nobody tried to suppress me, and there was no panic – far from it. In more rational circles, the scare caused by the Orson Welles *War of the Worlds* broadcasts is often cited as proof of what would happen. Yet, as pointed out in *Man and the Stars*, that broadcast came across as live coverage of a particularly murderous invasion. In a lesser scare in London in the 1950s, a flying saucer had been described holding an atom bomb over the city – hardly an effective test of a true contact situation. At

an early stage in the ASTRA discussions, the point was made to me directly: 'You think you'd be rational in the face of the unknown, but in a true contact situation you'd show the same unreasoning panic as anyone else.' Well, it seemed at the time that I had met the unknown, in the form of a star map drawn from the record of a radio signal, and my reaction was not fear but elation. If this was true, Man was not alone, interstellar travel was possible, logic was universal, communication was possible ... 'But,' said my accuser, 'you're an intellectual, you're well informed on the issue, you're emotionally prepared for this to happen, your reaction won't be typical.' In fact, as the letters poured in day after day, it became clear that from schoolkids to convicts the reaction was the same: if the probe existed it was good news, and people hoped it was true.

In the scientific world, and among those who claimed to share its viewpoint, the reaction to the proposed search for the probe was either neutral or just the opposite of the public feeling. Not long before, Professor Zdenek Kopal of Manchester had published his memorable request: '... should we ever hear the "space-phone" ringing in the form of observational evidence which may admit of no other explanation, for God's sake let us not answer; but rather make ourselves as inconspicuous as we can to avoid attracting attention ...'[6] One supporter of Professor Kopal was good enough to tell me that he would do all in his power to stop any attempt to contact the probe. Enquiries revealed that his powers were trivial.

Some scientists gave reasons for not answering the spaceprobe – pressure of other research, etc.; more often, correspondence was simply broken off without explanation; but in three cases of outright refusal, the precise words are well worth quoting. All three statements were made by gentlemen of considerable professional standing, but all were off the record, which is why they are anonymous here. The other factors they have in common should be all too readily apparent.

1). 'When we come across a phenomenon for which there is no natural explanation in terms of previously understood principles, we must not allow ourselves to consider the possibility that it may be artificial in origin.'

2). 'You must agree that it is better to do nothing about these things than to investigate them.'

3). 'Under no circumstances will intelligible signals be sent to the Moon Equilaterals, because that would constitute a biassed experiment.'

Such vehemence might be at least partly due to prejudice against

space travel in general, and interstellar travel in particular. One of the gentlemen quoted above is a well-known opponent of manned space research, often quoted by inquisitorial senators trying to cut the NASA budget. Some time ago ASTRA was visited by an aspiring astronomer who said, 'You must agree that the Soviet results from Luna and Lunokhod are far superior to anything done by Apollo' – a statement palpably absurd in terms of quantity of samples, intelligibility of selection, recording of site before and after, distances traversed, range of terrain covered ... yet he was amazed at our reaction, since he had absorbed without question the idea that anything a man does a machine must do better. Fortunately NASA does not share that attitude and goes for results on all levels – practical, technical and scientific – rather than for 'purity' of method, despite the protests thus aroused. When Neil Armstrong said 'To hell with the international scientific community' it may have been tactless, but one suspects that he had been sorely tried.

In the interstellar field, there is still widespread acceptance of Purcell's 'all this stuff about travelling around the Universe ... belongs back where it came from, on the cereal box'[7] from the early '60s. The continuing debate among engineers on the feasibility of interstellar missions has made little impression: in 1973, reporting on the Cyclops study, *Nature* observed: 'Not surprisingly, it turns out that electromagnetic radiation is the best tool for the job.'[8] By that time, the BIS Project Daedalus team was well embarked on its study of an unmanned probe mission to Barnard's Star. Reviewing the second volume of *Interstellar Communication* (ed. A. G. W. Cameron) for the BIS Journal in 1975, Eugene F. Mallowe wrote: 'They seem to be unaware that a generation of engineers has been at work churning out innumerable papers purporting to show the feasibility of interstellar flight ... The category of interstellar transport and propulsion methods was regrettably omitted from the Bibliography by editorial fiat.'[9]

A deeper question underlies that debate – one which we had already confronted in the ASTRA interstellar project. One distinguished scientist (again I spare blushes) advocated firing cargoes of fertilised human embryos into space at random, most to be destroyed but one or two perhaps to be found and nurtured by civilisations elsewhere. This, he declared, would be 'philosophically more satisfying' than a purposeful programme of exploration and colonisation. His hearers found no trouble in joining the Catholics present to say what they thought of his philosophy; but, moral issues aside, it seems perverse to the ideals of science to prefer a

programme whose results are unknowable. Another scientist, no less eminent, told us that it was more sophisticated to communicate with other intelligences by radio than to launch manned interstellar missions. He quoted Purcell's analogy[7] of the picture gallery: it is more mature to look at the pictures and learn from them than to want to touch them. Again the society rose in protest – not just against the general principle, but also against the implication, false to scientific enquiry as we understand it, that it is more sophisticated to remain ignorant of the conditions in uninhabited systems. And, as Gerry Webb was to point out, reviewing *Interstellar Communication* for *Spaceflight*,[10] 'if the expected contact does not happen ... then after hundreds of years of first listening and then signalling fruitlessly, our (presumably by then) highly technologically competent civilisation will be left with no alternative than to go and find out why no one answered our call'.

One of the oddest paradoxes of the 'Two Cultures' is that the philosophy of science is sufficiently difficult to be a final year honours *arts* subject, and therefore well outside the time commitment available to the science student. As a philosophy student with scientist friends I was aware of the problem, but the spaceprobe affair fully brought it home to me. One of its many aspects is the insistence on treating possible CETI phenomena as if they were purely 'natural' ('under no circumstances will intelligible signals be sent ...'), refusing to make allowance for the assumptions which might be made by rational minds at the other end ('... because that would constitute a biassed experiment'). It also involves the fundamental confusion between 'verifying' hypothetical processes involved in a natural cause-and-effect (e.g., 'the motions of double stars show that they conform to Newton's Law of Gravitation') and verifying hypothetical *facts* (e.g., 'there is a spaceprobe in the orbit of the Moon'). A sure sign of such confusion is a preoccupation with the 'respectability' or 'propriety' of the enquiry rather than with getting results.

It should be stated, then, that there is nothing in Western philosophy to which one can appeal to justify statements like 'It is philosophically more satisfying to send machines rather than men' or '... to communicate by radio rather than send ships'. As every first-year student learns, Western philosophy is descriptive, not prescriptive: it analyses the underlying principles of rational thought and ethical behaviour but does not provide precepts or a scale of values. In the more general everyday sense of the word 'philosophy' there is no value system I know which would make it better to look at a planetary system than to visit it; on the contrary,

'armchair traveller', 'bar-room mountaineer' and 'piloting a desk' are all terms of derision. Scientists stake a great deal on the purity of their ideals; where they clash sharply with public opinion, as in Professor Shockley's hypotheses on racial characteristics, the cry is 'we must go forward in the pursuit of truth without fear or favour' – a noble sentiment, however misdirected at times, and not one which leads logically to such propositions as 'You must agree that it is better to do nothing about these things than to investigate them' ... nor to a scale of values on which unmanned probes or radio conversations are better than going to see for oneself. On space research in general and CETI in particular, one begins to suspect that something in the thinking is badly wrong. There are widely held views in astronomical circles that it is better in principle to explore the Solar System with machines than with men; that interstellar travel is impossible, or, if it is possible, is undesirable, and either way should not be discussed; that it is preferable to converse with other intelligences by radio, with many years of timelag, rather than to meet them face-to-face; and there are strongly individual views that even such meeting of minds is to be avoided. If we strip those views of their supposedly 'philosophical' justifications – which are worthless if not harmful in this context – then we are faced with nothing more 'sophisticated' than an unrecognised fear of the unknown.

Carl Sagan has spoken at length about the various forms of 'chauvinism' – oxygen-chauvinism, liquid-water-chauvinism, ultra-violet-chauvinism, etc. – which in his view blind scientists to many possibilities for extraterrestrial life. Of all such blinkers, 'unknown-chauvinism' would be the most misleading, time-consuming and wasteful. Wherever a line of argument was unconsciously recognised as likely to produce significant results the consensus of scientific thought would shy away from it, throw its energies into blind alleys, and denounce anyone who tried to open up the frontier marked 'Here be dragons'.

There is, of course, a large body of popular literature dealing with alleged past contact, virtually all of it sensational, inaccurate and misleading. Most of the remainder – books like Ronald Story's *The Space-Gods Revealed*[11] – have been written specifically to expose the phonies and are not themselves serious investigations of the past-contact possiblity. But the odd thing about the apparent consensus in the scientific world is the condemnation not of the bad scholarship but of the *subject*. It is, for example, common practice to refer to the subject as 'von Dänikenism', although von Däniken

was neither the first nor the worst writer in the field; but the label provides a convenient guilt-by-association implication that anyone who discusses any aspect of the subject must be equally sensationalist and inaccurate.

Reaction to the said crop of books, and particularly von Däniken's, is often given as a reason for refusing to allocate serious discussion to past contact. It should hardly be necessary, but unfortunately it *is* necessary, to point out that the reasoning is entirely spurious. In any other field of enquiry scientists would be outraged by the suggestion that a single sensationalist writer could muffle the entire scientific community and prevent all rational discussion. For example, I complained to the author of an otherwise excellent book on interstellar travel and communication that he had not mentioned past contact, even in refutation. His reply was: 'von Däniken has given the topic such a bad name that I could not risk giving it any space, for fear of cutting myself off from contacts whom I need in order to make a living.' If such voluntary censorship were the general reaction to outside speculation, science would stop dead. *The Secret Life of Plants* would make further progress in botany impossible; *The Bermuda Triangle* would bring oceanography to a halt; pyramid power would bring physics to a standstill and Velikovsky's absurd notions would stall astrodynamics for a generation. But I could not even convince the author in question that his scientist friends would not be *right* to take reprisals had he brought up this particular topic.

Mention of Velikovsky brings up the point that, in other fields, not only does science march on unimpeded by outside speculation, but it consciously shares the spotlight in the name of fair play. *New Scientist*, for example, remains proud that it gave Velikovsky a hearing, and cited that circumstance as a justification for a prolonged debate on Yuri Geller and paranormal claims in general. Not a year goes by without someone reopening the Velikovsky debate to make sure there has been no miscarriage of scientific justice – a weekend conference, sponsored by Glasgow University Department of Extramural and Adult Education, is closing as I write. And, while there is criticism of the methods and results of Professor John Taylor (on spoon-bending) and Professor Alan Hynek (on UFOs), nobody seems to question the rightness of enquiring. If 'unknown-chauvinism' is at work, of course, UFO investigations will be acceptable precisely because they are apparently a dead end, unlikely to reveal an encounter situation – present or past.

On the historical side of the topic, the pattern is likewise all too

familiar. I recently had occasion to ask a well known researcher if he had come across any oddities in a certain field, perhaps indicating the presence of visitors? No, he replied, 'but in any case, that whole class of enquiry is thoroughly bad scholarship'. He was objecting not to a particular hypothesis or approach, but to the entire topic, in which no form of enquiry could be valid. ('If we come across a phenomenon we cannot explain ... we must not allow ourselves to consider the possiblity that it may be artificial ...')

Likewise, I was drawn some time ago into a correspondence in the SFWA *Bulletin*. Replying to my letter, L. Sprague de Camp wrote, 'To see the myth of the extraterrestrial enlighteners debunked once and for all, I refer Mr Lunan to *The Space-Gods Revealed*, by Ronald Story.' Story himself makes no such sweeping claim: his target is announced in his subtitle: 'A Close Look at the Theories of Erich von Däniken.' He states in the Appendix that he has not made a detailed study of (equally bad) books by other writers, which were consulted only to gain a general impression of the field. And even von Däniken's best known claim, that astronauts created mankind (for which he offers no hard evidence, and the hearsay evidence is all spurious), Story writes: 'This hypothesis, while quite unlikely, is not logically or physically impossible; in fact, one underlying supposition – that intelligent life may exist elsewhere in the Universe – is now denied by practically no one who is reasonably well informed on the subject.' Story goes on to a detailed breakdown of von Däniken's faulty evidence and reasoning but undertakes no discussion of the possibility that Earth may at some time have been visited. Far from ruling out the possibility, Story does not in fact discuss it directly at any point in the text.

In this example and the previous one, two distinctive symptoms of 'unknown-chauvinism' might be detected: concern with the supposed impropriety of the enquiry, rather than with the facts, in the first case; and accepting that any attack on any part of the subject closes the whole enquiry 'once and for all', in the second.

The emphasis on propriety rather than truth is particularly worthy of attack. It contradicts the scientific ideal that any question, no matter how startling, may be asked without fear or favour. But it also highlights the logical distinction I drew between testing a hypothesis, in the scientific sense, and establishing a fact. For example, Newton's 'Law' of gravitation was a hypothesis which was considered to be verified because it correctly predicted observable phenomena, within the limits of measurement of the day. In time more subtle observations revealed discrepancies for

which Einstein's more complicated theories were able to acount, in addition to satisfying new tests of prediction. Newton's account of gravitation has not been invalidated – it remains 'true' as a description of certain specialised cases within the more general Einsteinian framework – and we cannot rule out the possibility of further evolution of our insight in the future. By contrast, either the Earth has been visited or it has not, and it should be possible in theory to answer the question with a definite 'yes' if true. (A definite 'no' would be harder to obtain, but if it is the case we should try to establish it as firmly as possible. The most likely implication, that we are one of the first high-technology civilisations to migrate into space, is not exactly trivial.) The factual knowledge gained from archaeological discovery is not provisional, in the sense that any theory of physics must be: after Schliemann found the ruins, the existence of Homer's Troy could no longer be queried in the way that theoretical challenges are periodically aimed at Einstein. To say that all past-contact enquiry is bad scholarship is like saying Schliemann was wrong to look for Troy on the basis of myths – even though Troy actually existed. In chauvinist terms, Schliemann's dig was unquestionably a 'biassed experiment'.

In *Intelligent Life in the Universe*[12] Carl Sagan suggested three criteria for identifying a possible contact situation in the past. These were: (1), an account committed to writing at or near the time; (2), a major effect on the civilisation contacted; and (3), no attempt to conceal the extraterrestrial nature of the visitors. I have discussed this problem at length with a former intelligence officer, Alan Evans, and in our opinion Sagan's criteria are too demanding in some respects and too lenient in others: e.g., the contacted society might not have possessed writing at the time, and might have insisted on deifying the visitors; they might not have recognised the extraterrestrial connection, especially if they did not witness the landing; nor is it hard to think of reasons why visitors (well meaning or otherwise) might decide to accept deification in the circumstances. There are in fact no alleged instances of contact which wholly satisfy Sagan's criteria; but it seems to us that on analysis they serve primarily as guidelines to preserve the reputation of the investigator, in relation to specific alleged instances, rather than to answer the question 'Has Earth ever been visited?'

In the course of the spaceprobe affair I evolved four criteria which I believe to be more helpful. When considering past evidence as possible indications of Contact, we should look for:

(1) recognisable principles of technology;

(2) rational purposes for the supposed Contact;
(3) information freely given;
and, resulting from these three,
(4) further possible investigation capable in theory of verifying or disproving the supposed Contact.

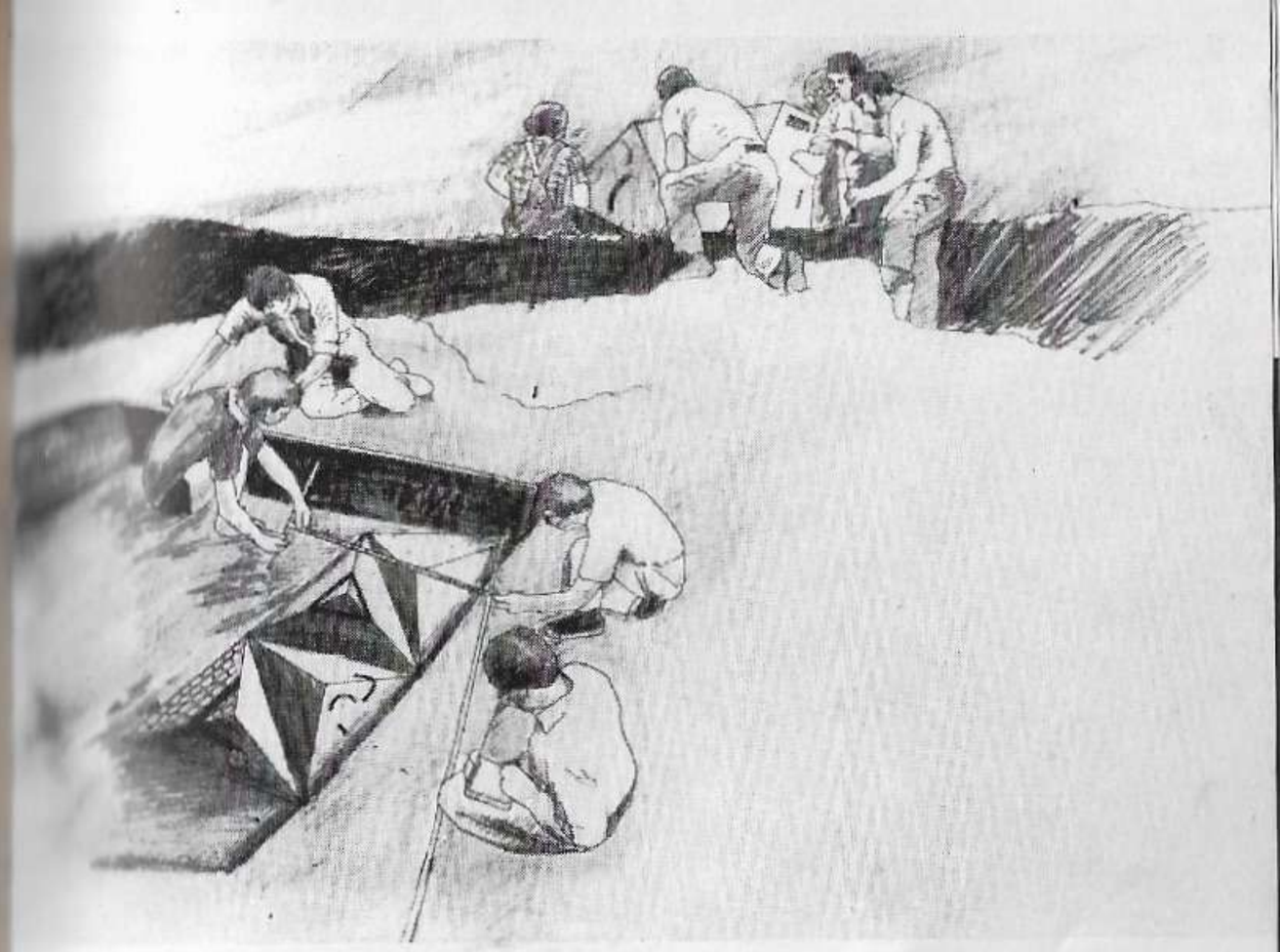
It should be noted that the postwar hordes of UFO sightings, including alleged meetings with UFO occupants, have failed to meet these criteria singly or in groups. From the viewpoint of an investigator in a thousand years or more, however, it might seem that they satisfy Professor Sagan's.

Criterion (3) is the one which may not be satisfied. It is easy to imagine that visitors might choose not to give information, especially if they were conducting an investigation prompted by conservationist motives. If that were the case, however, presumably they would also be systematic about removing artefacts and our chances of verifying their presence here would be remote. What follows is based on the assumption that we are intended to find out, sooner or later, who came here (if anyone) and why.

Almost certainly, extraterrestrial artefacts are the only acceptable category of proof that contact has in fact taken place. It is hard to imagine any other category of evidence – no matter how good the instances within it – which would carry sufficient force to make its acceptance anything but a matter of opinion. Artefacts can be viewed in four divisions: objects deliberately planted, objects abandoned, objects on the earth, objects elsewhere in the Solar System. Objects elsewhere in the Solar System are not likely to be found, at the present stage of exploration, unless they deliberately attract attention by responding to radio signals received from Earth. One of the attractions of the spaceprobe scenario was that it seemed to be a positive instance of this kind; it is also one of the few which could theoretically be verified without extending our present space programme.

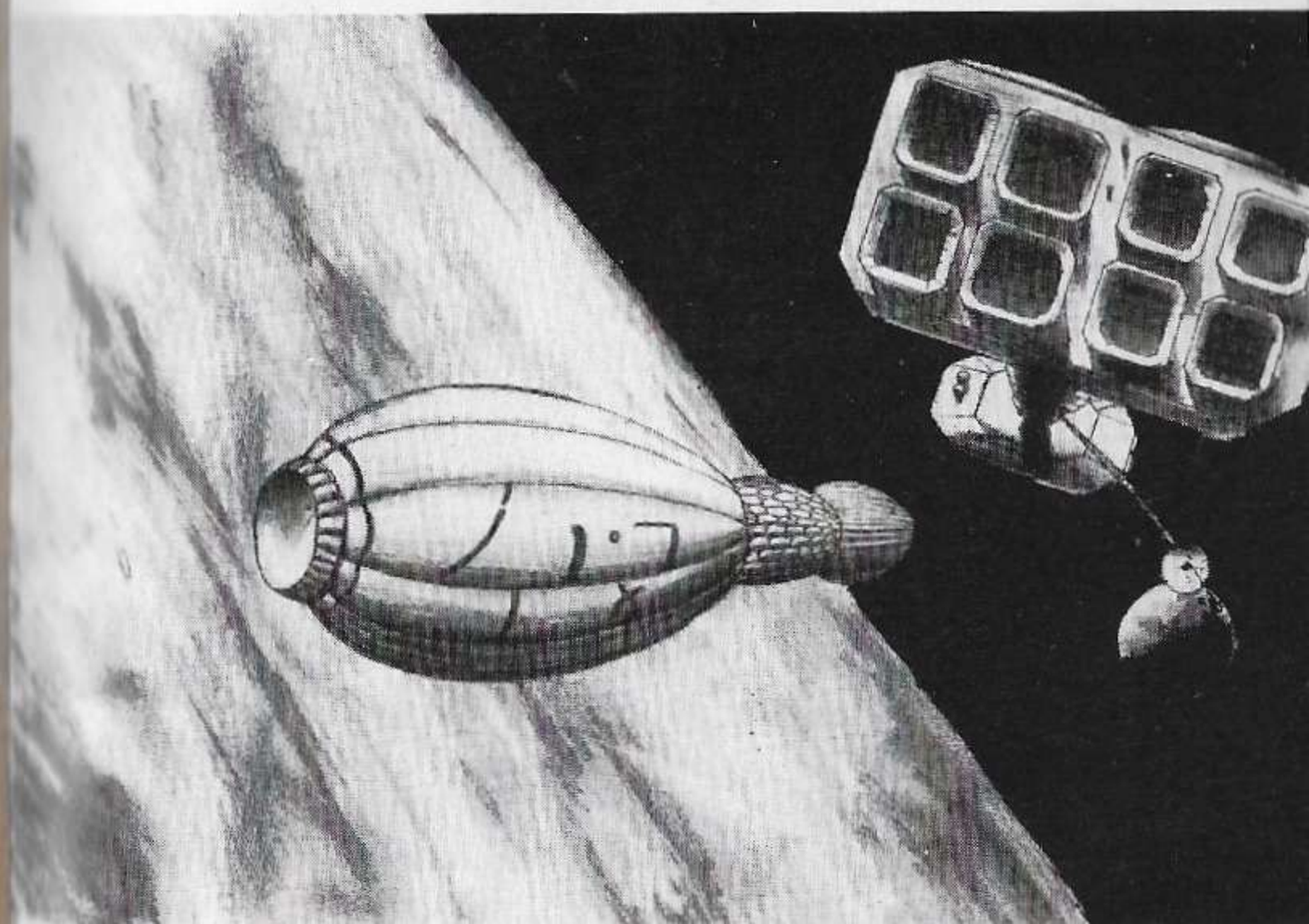
Objects on the Earth could fall into an almost infinite range, but for our purposes can be classified as: (a) objects deliberately left to be found by us (information, relics, monitoring devices or communications systems); (b) objects deliberately concealed from us (monitoring or other devices serving extraterrestrial purposes); (c) objects discarded; (d) vehicles or installations wrecked or abandoned.

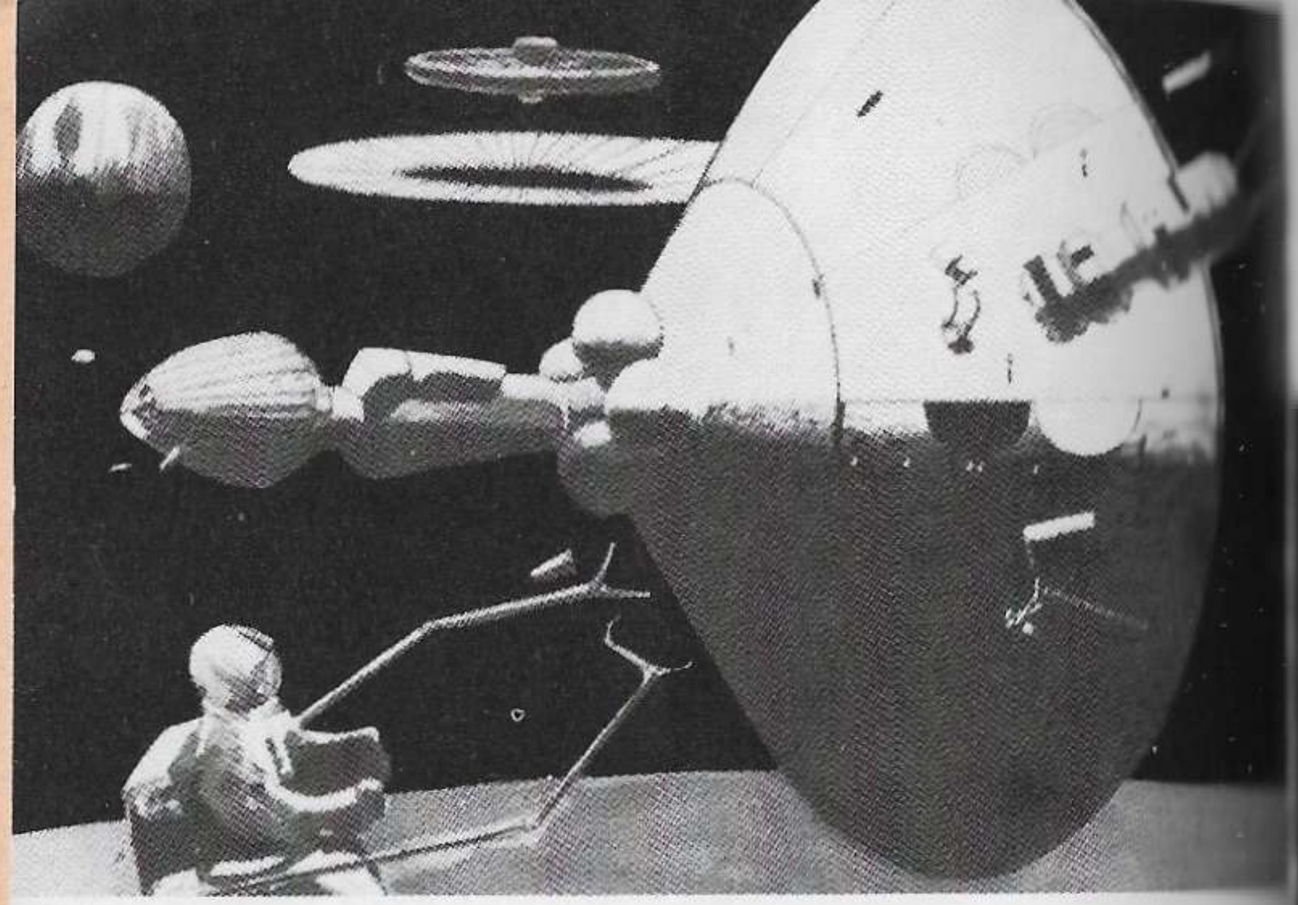
Category (a) objects are meant to be found and presumably signposts exist. Category (b) ones may give themselves away, if still active, if we now have the technology to detect them and their



Members of an archaeological dig painstakingly unearth alien artefacts left long ago as a 'cache' for Man to discover (see page 76).

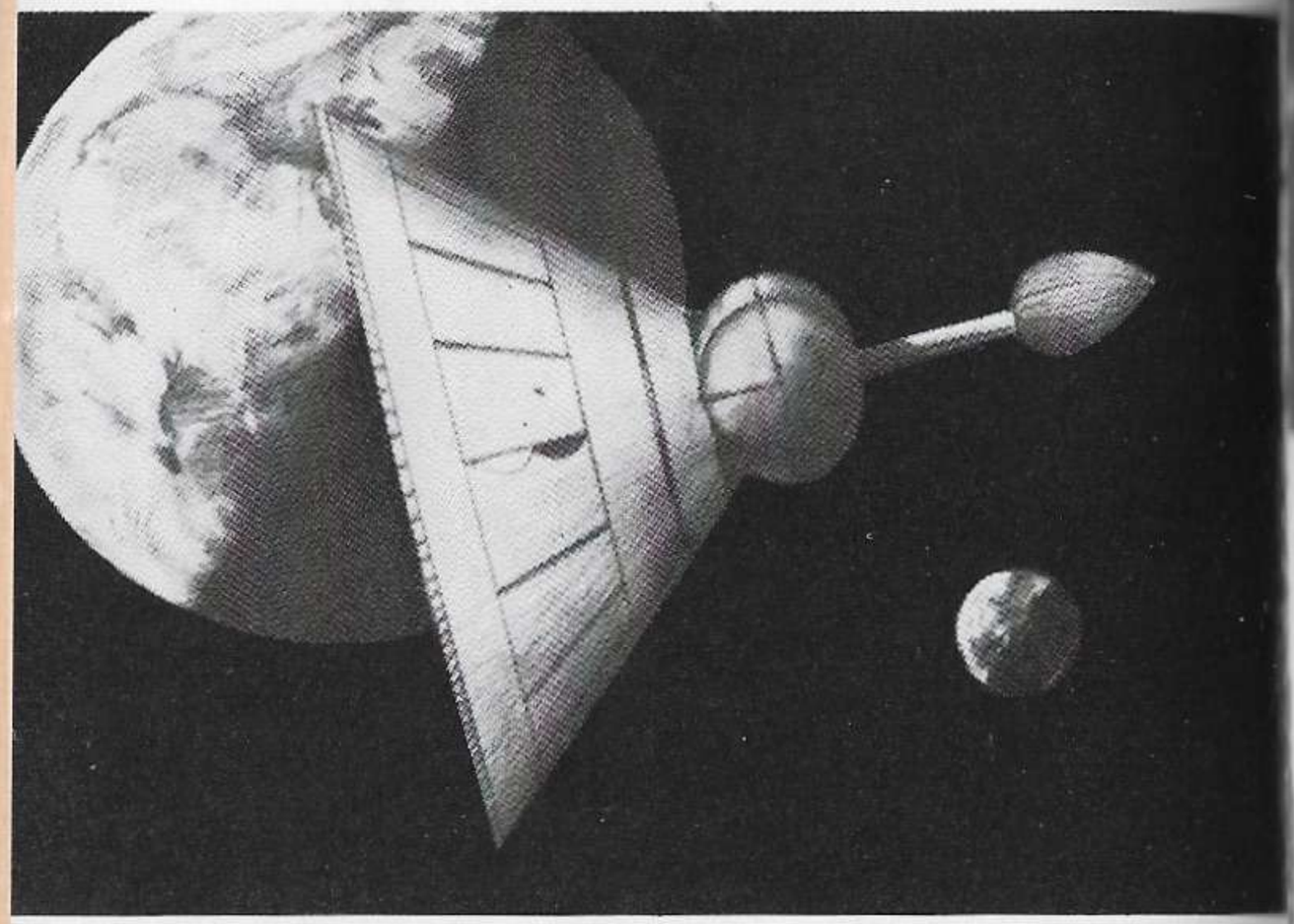
A manned NASA deep-space probe encounters a crippled airship of alien origin in orbit around Jupiter (see page 58).

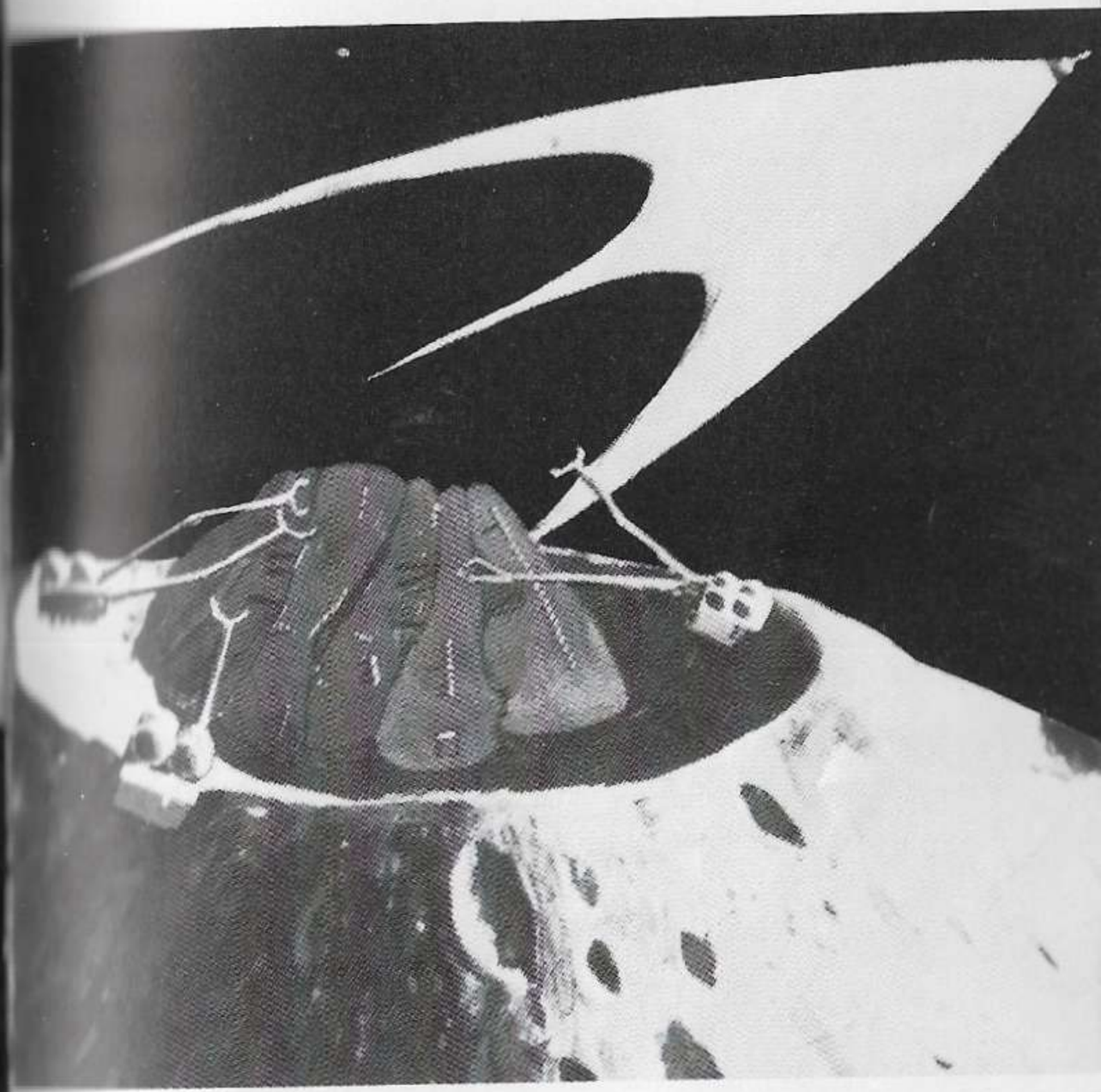




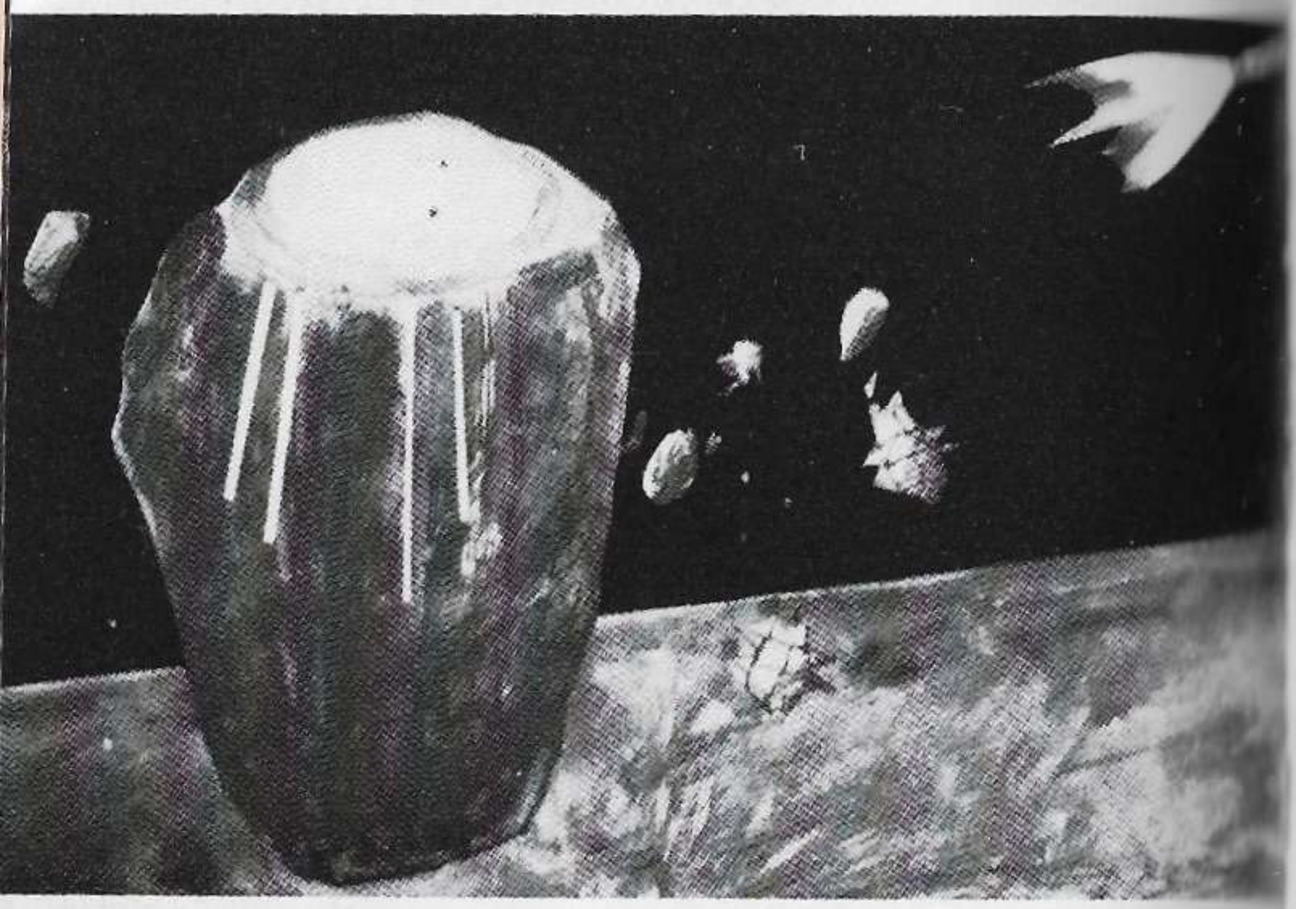
3 A von Neumann probe in the process of construction in orbit around Callisto, the second largest of Jupiter's moons, by men using special handling machines (see page 102).

4 A von Neumann probe in Earth orbit.



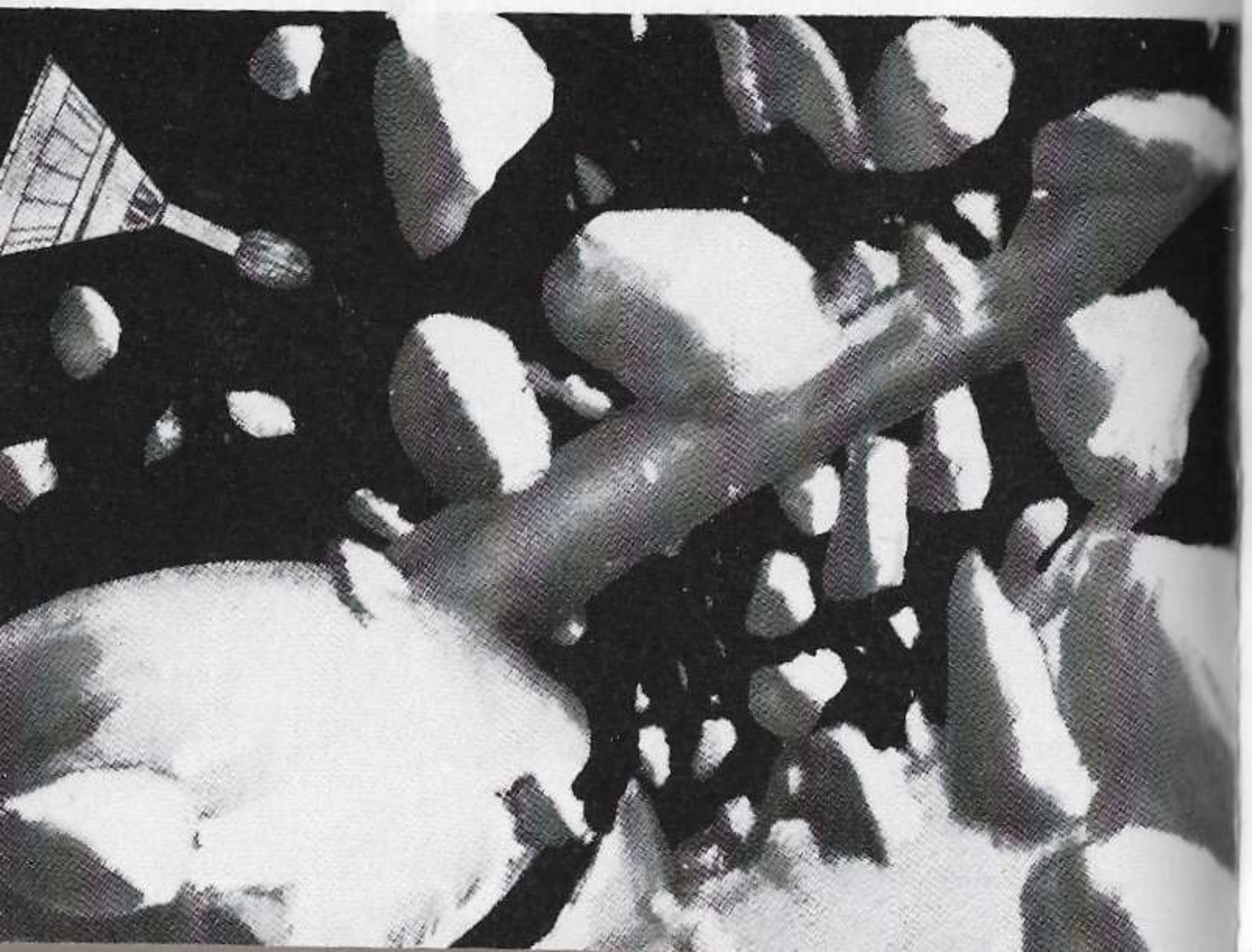


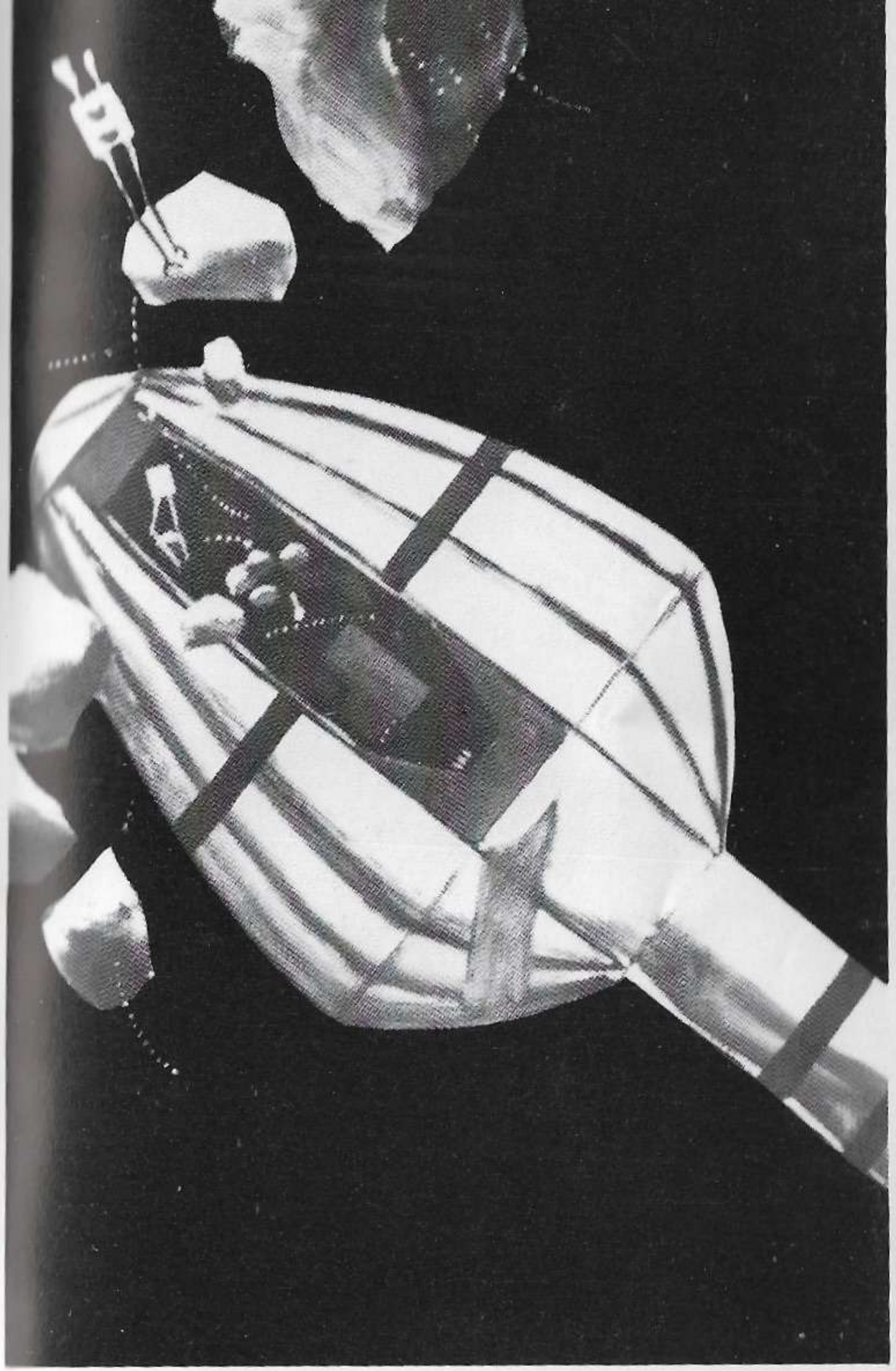
5 A von Neumann-type probe departing the Solar System having left behind it an 'egg' (see page 103).



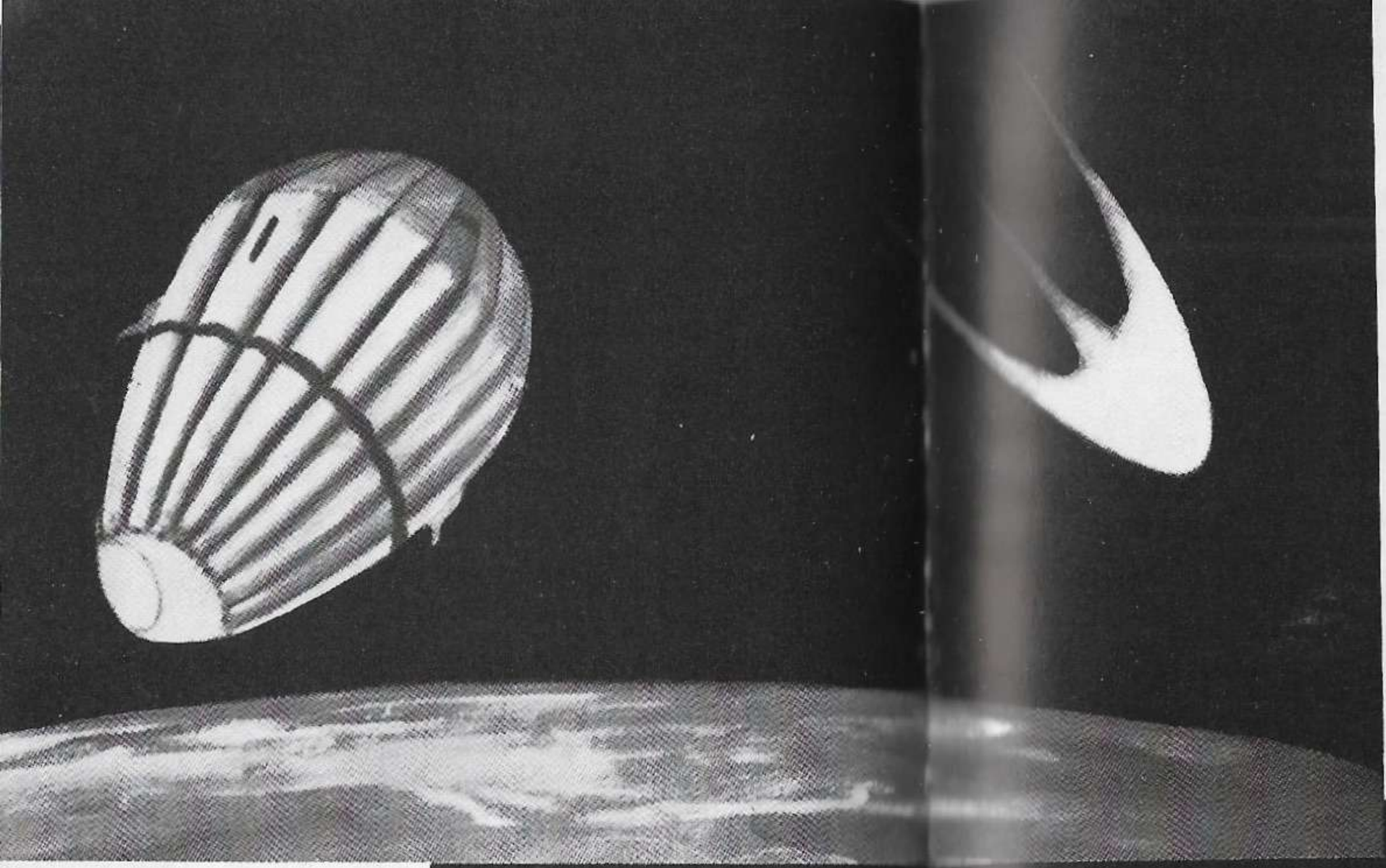
6 An asteroid in the process of conversion into a probe factory by automata from a visiting alien probe of von Neumann type (see page 110).

7 A von Neumann probe gathering construction material from the rings of a Saturn-type planet (see page 102).

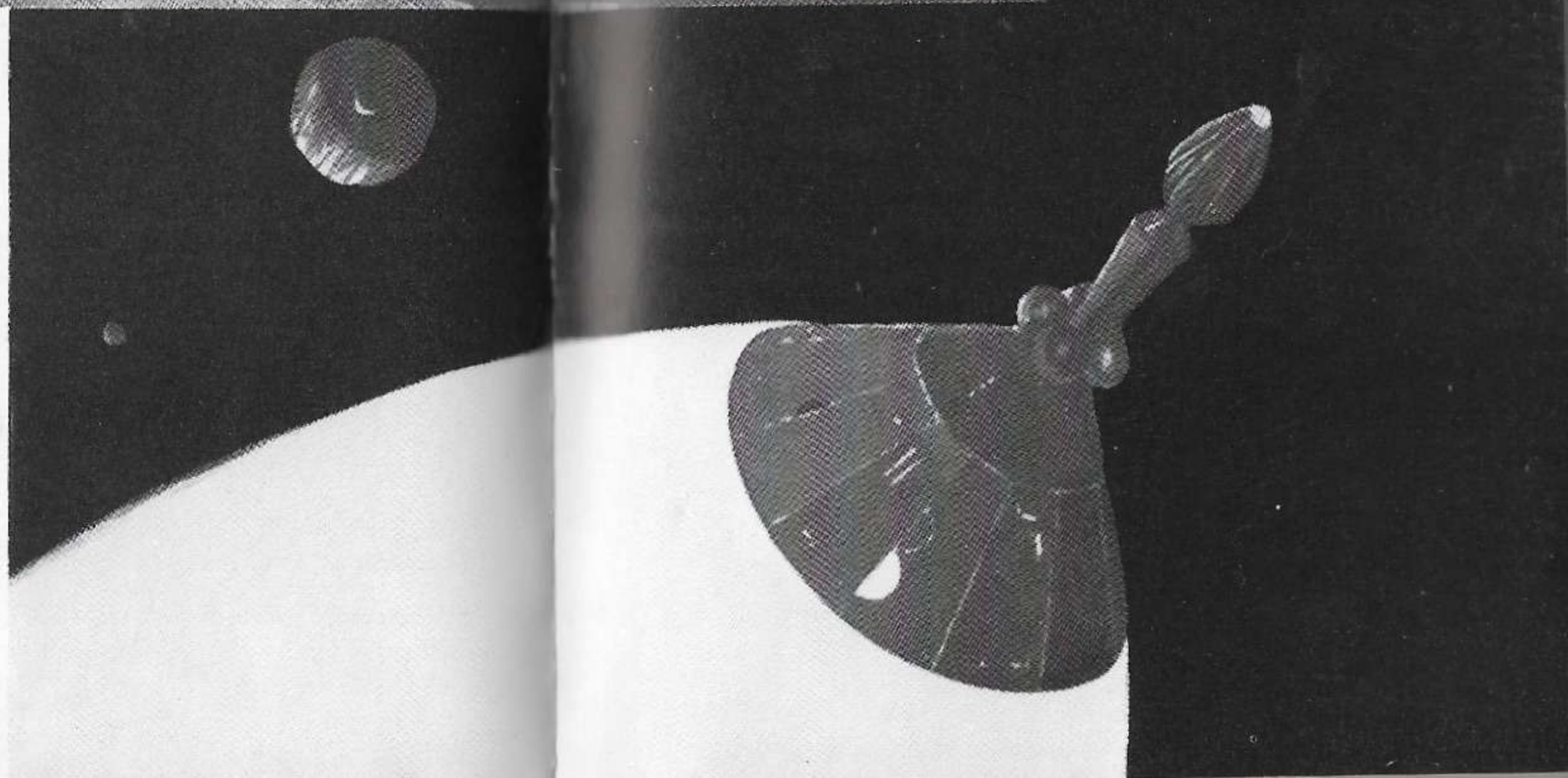




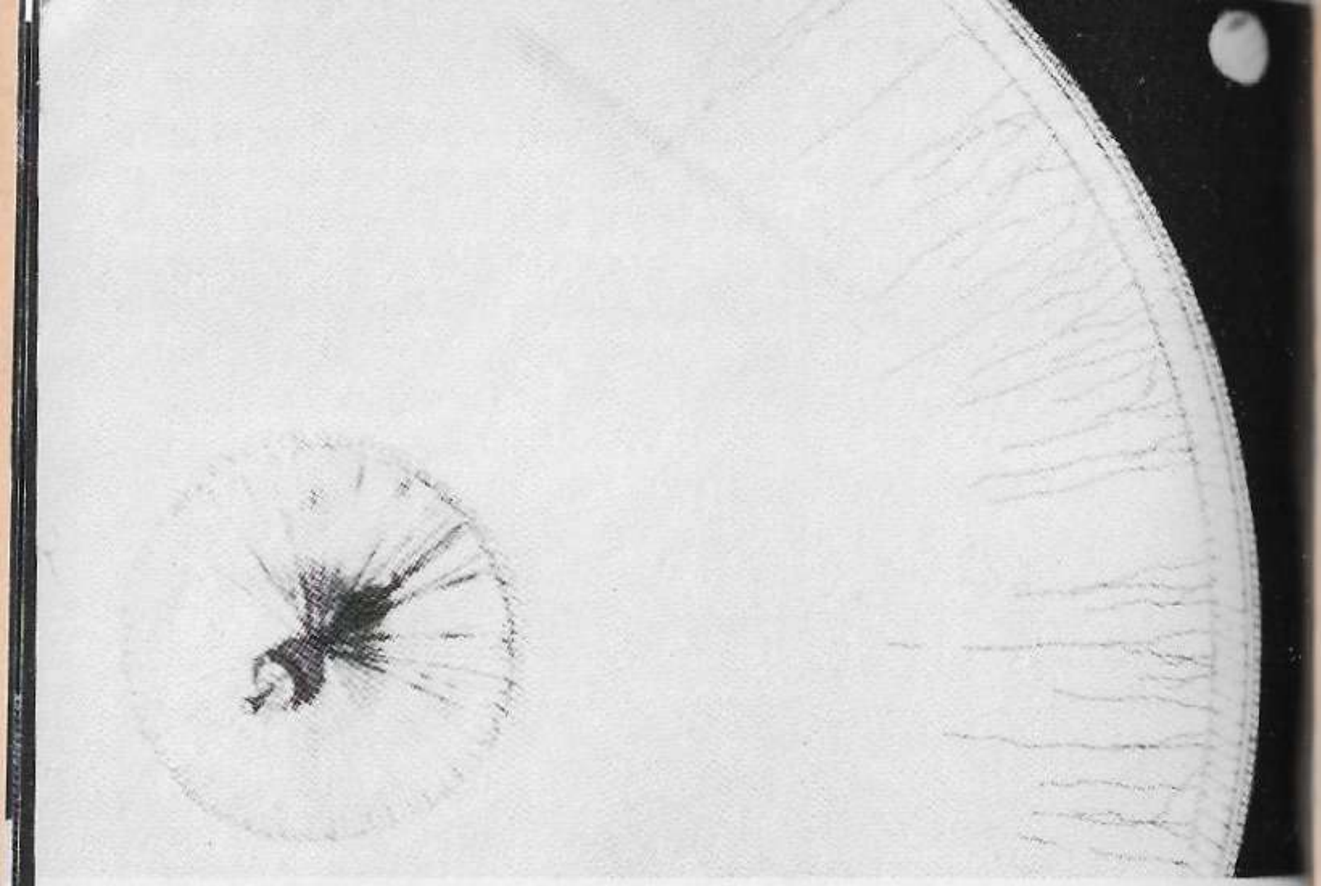
8 The head of a von Neumann-type probe using the materials it has gathered from the smaller bodies of the star system it is leaving to manufacture a new von Neumann-type (see page 103).



9 The databank head of a von Neumann-type probe left in orbit around an Earth-like planet. In the background, a new probe 'lights up' as it leaves the system heading for interstellar space.

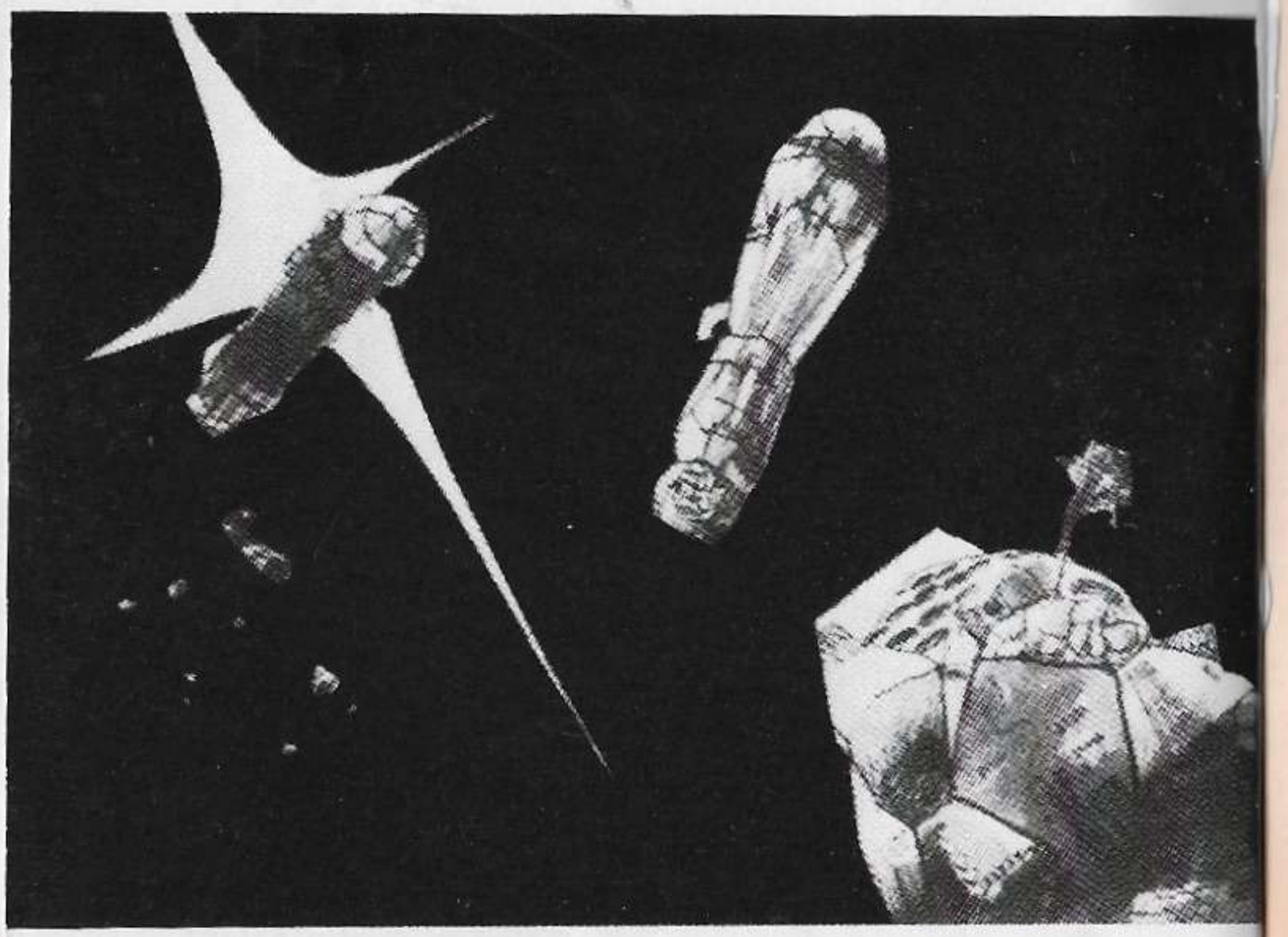


10 A von Neumann-type probe enters a new solar system (see page 102).



11 A subprobe detached from a von Neumann-type factory. It is using the solar sail principle as a means of interplanetary propulsion.

12 A 'college' of von Neumann probes exchanging information (see page 106)



makers have had no opportunity to switch them off or remove them. Category (c) seems unpromising until we know what happened and where it happened. At first sight category (d) seemed most promising, but the hope was not borne out. Unless a space vehicle got into difficulties near the ground, or was overwhelmed by some natural catastrophe like a storm, earthquake or volcanic eruption, there is little chance of leaving recognisable wreckage. At an early stage in our correspondence Alan Evans suggested surveying catastrophe sites such as Santorini in search of wreckage, but the chances of finding anything are not good. According to a Rolls-Royce technician we consulted there is not much chance of recognising high-technology equipment, after thousands of years in the hostile free-oxygen, liquid-water, high-gravity environment of the Earth's surface, unless deliberate steps have been taken to preserve it.

Thus the probabilities come down with some weight in favour of category (a), assuming that the assumption of criterion (3) is correct. Our best prospect of success is to search for artefacts left and signposted for us. On that basis there could be four classes of possible evidence.

(A) Artefacts of incontestably extraterrestrial origin – data capsules, spacecraft, monitoring devices or installations.

(B) Photoreconnaissance or electromagnetic anomalies leading to the discovery of class (A) evidence.

(C) Clues built into long-lived man-made structures (particularly astronomical clues) leading to the location of class (A) or (B) evidence.

(D) Legendary, mythological or archaeological material (man-made) reflecting some aspect of a past contact – if one occurred. All the 'von Däniken material' allegedly falls in this class, but in fact very little of it stands up to preliminary investigation and the remainder is far too tenuous even to be classed as 'evidence'. The only possible uses for such material are to indicate possible historical and geographical areas for investigation in the other three classes, or for possible correlation with that evidence if found.

In *Man and the Stars* I attempted a preliminary analysis of the class (D) material advanced by von Däniken in his first two books, plus seven books by other authors. The result carried so little weight that it had to be presented in humorous terms and inevitably was coloured by the Epsilon Boötis senario, now discarded. Even so the most favourable conclusion was that the Earth had not been visited more than four times. Further research has not extended those

possibilities: the general trend has been to strengthen the alternative possibility that Earth has not been visited more than once (if it happened at all), with 'frozen' memories appearing in the folklore of later cultures. There does appear to be a possible correlation with class (C) evidence, if valid; but of course coincidence cannot be ruled out.

Thus we come down at last to class (B) as the make or break point. The only effective way at present to find artefacts, prove Earth has been visited and establish that we are not one of the first civilisations in our part of the Galaxy, is to look for photo-reconnaissance or electromagnetic anomalies. The precise nature of the traces, if they exist, will depend on the technology and purposes of the visitors, and rather than spell out a list of possibilities, it would be better to rely on the photo-interpreter's judgement or intuition that he has found something unusual. But, since Earth is under intensive study from the air and from orbit for military and civilian purposes, it seems that the cost of such an investigation would be limited to the gathering, interpretation and investigation of possible instances. Some thought has been given at ASTRA to the handling of such a project and we will be very interested to hear from anyone in a position to set it up – or even to help in pursuing class (C) and (D) leads with photographic evidence. But it must be emphasised that the object is to locate class (A) evidence if it exists – not to launch a new set of sensational red herrings in class (D). On the other hand, such a search seems the best chance before us at present, if we are not alone in the Universe, to establish the facts in our lifetimes.

8 – Meditations of the Heart

Artistotle taught that the seat of the emotions was not the brain but the heart. He was wrong. Anyone who made a statement to the effect that the brain was the seat would be nearer the truth but they would have a too selective view. The true seat is a particular interpretation of the entire human body which takes into account not only the nervous system but the hormonal balance and much more.

By emotional behaviour most people mean irrational behaviour. This begs the question. What is rational behaviour? Is it activity directly and only related to reasoning? Is it, on the other hand, related to the sociological imperative created by us and dictating to us? How do reason and emotion relate to empathy, imagination and curiosity?

Do they relate at all to the ETI?

Take curiosity, an aspect of terrestrial behaviour, a seeking out of new significances within the Universe as we interpret it. We do not know that curiosity is the only basis for activities which make beings elsewhere aware of new significances. If curiosity is truly the psychological foundation for scientific activity then we cannot expect the scientific method to be widespread among ETI. This is not to say that high mental lifeforms will prove to be incapable of activities which we might interpret as being scientific or technological in their nature. The problem lies with our very interpretation of these activities.

We must be prepared to broaden the nature of what we consider to be science, technology and perhaps even curiosity itself if we are to relate them to ETI behaviour. For example, we are unaware of how it would be possible to cross interstellar space without a sophisticated grasp of mathematics and logic which we employ in system designing. This does not bar the almost certainly non-mathematical AMLs from moving between the stars. They too will have to employ sophisticated use of their 'brain functions' as will we with ours in order to do so. We cannot do it without maths: this is a description of our limitations, not of theirs.

Let us recap on the possibilities seen by most CETI scientists searching for radio signals. Firstly, there may be a beacon which is attempting to set up a communication link with as yet undetected civilisations. Secondly, there may be the possibility of us intercept-

ing a message being transmitted from one ETI to another. Finally, there is the chance that we may pick up the expanding sphere of internal communications of some fairly nearby system – just as they may pick up the internal signals which have been expanding from Earth for decades now.

The first two seem somewhat anthropocentric in their conception and the latter may prove totally incomprehensible. It may well be the radio-communication 'songs' of a mental lifeform which uses radio to communicate in the same way that our cetaceans use sound. If this is the case, then we will be on a sounder base for comprehension once we discover and begin understanding the world of dolphin significances.

There is a possible other form of signal which may be only marginally associated with communication. Something of the nature of an interstellar radar pulse may 'hit' the Solar System to read it for aspects which the ETI would find significant. The pulse may not be comprised of one modulated signal but of many of many different kinds on a variety of wavelengths only some of which, if any, will correspond to radio frequencies. Should we intercept the signal it will give us information, no matter what type of signal it is.

Let me dwell for a moment on the idea of the sophisticated 'radar' pulse. Radar is an inappropriate description for the exploratory device suggested by Dr Alan Cottey[1] of the University of East Anglia. Somewhere in between the use of radar and a miniaturised spacecraft for the purposes of interstellar exploration there may exist highly versatile non-linear but wave-like phenomena capable of travelling at near light speed and of interacting in a highly sophisticated manner with their target environment.

Another suggestion is for the transmission at near light speeds of biological materials which then interact with the target system to produce a variety of biological machines capable of exploration and returning data to the home planet without actually returning physically themselves.[2]

Perhaps the two suggestions could even be married in a number of ways. The pulses could themselves be so highly organised that they constituted a high mental lifeform in themselves; a point which Alan Cottey has underlined with a warning that it could be folly to attempt to make distinctions between the ETI and its artefacts. Alternatively, the pulses themselves could produce the biological machines.

Whether or not they would actually be mental lifeforms is a moot point with regard to such sophisticated signals. If they were so

highly organised that they did not simply bounce back an echo but the whole signal-pulse package system was capable of returning highly processed data to its source it would be of the stature at least of a superb terrestrial computer if not actually of an artificial intelligence.

Some brave individuals 'guesstimate' that there are 'civilisations' emerging in the Galaxy at the rate of one every decade.[3] Let us substitute ETI for a 'civilisation' and we may be on the way to establishing a better basis for relationship between ourselves and other mentation in the cosmos. Being completely unable to appreciate the motivations of the ETI we will be totally at a loss to understand the prime movers of their interstellar urges. This being the case, we cannot be sure that they will be interested in the dissemination of knowledge.

Given that there is no way of determining the motivation behind the ETI's interstellar urge, we cannot anticipate what strategies will be considered and employed to satisfy it. This being so, we should regard all strategies as being equally likely. The more strategies which we dream up to satisfy our own urge the less likely we can consider any individual one as being the best for the ETI.

What we must look for is the strategy which gives the best prospects for encounter under these conditions. There are two imperative bases for such a strategy. The first and most important is that it must employ a system which is not solely rooted in our own mathematics and technology. The second is that, even if it is adopted only very rarely throughout the Galaxy, say once every one or two million years, and the originating AML soon loses interest in it, we still have a fairly good chance of encounter.

Both of these conditions exclude radio communication: the first because, although there are natural radio transmitters galore and it is simple enough to imagine an ETI with a natural radio ear, the codes would have to be mathematical before we could understand them (although computer analysis may show statistical improbabilities in some and indicate that they may be ET in origin); the second excludes it because, if an ETI loses interest in radio signalling rapidly, we simply do not have time on our side.

The one concept which holds out promise to me is that of the renewable space probe.[4] This is basically a system which is capable of reproduction. The mathematician John von Neumann took the concept of a machine which could duplicate itself and worked it into a precise mathematical description.[5] A system of interstellar exploration based on such machines would be very efficient indeed.

Von Neumann's work anticipated to a remarkable degree what

was subsequently discovered about the ways in which known living systems reproduce and repair themselves. This is what I find fascinating. The ant with its lack of mathematical or biological science reproduces heartily, as do whales and viruses. An ETI would have to employ such a system within its own frame of significances but the system itself would not be rooted in these any more than it is in our maths and technology. We cannot say how they might employ this quasibiological system, but we can make guesses about ourselves.

Assume that in a century hence we have the capabilities to build both a von Neumann-type machine system and an interstellar probe. There is then the possibility of constructing the self-reproducing probe-system. What must be recognised is that if this endeavour is embarked upon it will be enormously expensive, much more so than a non-reproducing probe. The great advantage of it is that once the vehicle has been built and is fully operational all our capital costs on probe building are over. For that investment we have a system which can explore every star system, every interesting astronomical object in the Galaxy.

Who can say what our technological capabilities will be a century hence? It may take much longer or much shorter, but there are a number of elements which have to be incorporated into the design. The probe will have to be a system capable of replicating itself several times over in almost any environment it is likely to encounter, perhaps even interstellar space itself. It must be able to communicate with Earth and other probes. One of the problems which we can currently foresee is that of a propulsion system. Hopefully, as we already have a fair design for an interstellar probe at the present time, a variety of propulsion possibilities will be both evident and in some cases actually in use by the time of the von Neumann probe's construction.[6]

By its very nature the probe will be able to process all its own requirements over a very long period of time. This means the machine will take care of providing itself with suitable materials and fuel for the interstellar journey and its self-maintenance at the other end.

The process would work something like this.

A fully automatic probe factory would be set up, possibly in the asteroid belt or in orbit about Jupiter. This would assemble probes and despatch them. The exploration strategy would probably be fairly straightforward. Probes would be sent out to the nearer stars continually until the returning signals indicated that they had all been successfully 'colonised'.

Probes *en route* to stars successfully reached and monitored would then select their secondary targets. These would lie beyond the immediate group that the Solar System factory was interested in. They would inform the factory and other probes in their vicinity of the choice. This expanding net would be passing back to Earth data concerning the interstellar medium through which it was passing.

On arrival in a target system the probe would seek out some suitable site and lay its 'egg'. This would be a complex of computer elements and handling mechanisms. This system would then set about creating more elements which it would add to itself in a cycle of enhancement until it had fully developed into another automatic probe factory.[7] As soon as the first planetary probes had been successfully deployed the factory would signal Earth that the star system was being monitored. The next task would be the building of a batch of interstellar probes each similar to the one which was the factory's parent.

The planetary probes would be self-repairing and self-maintaining to a great extent but, when the maintenance and repair systems finally broke down, the factory would produce others. As the factory approached the end of its own lifetime it would create a quasi-star probe not designed to travel from this system but merely to lay a new 'egg' from which a new factory would spring.

It might be relevant to give the planetary probes a capability to produce such a quasi-probe among themselves. This would be the equivalent of a beehive selecting a female to replace the queen when she dies. Just as special procedures can turn this female worker into a queen, so might the probes turn one of their own into a quasi-probe for the purposes of 'egg' laying. This would ensure long-term monitoring of not merely the system but whole sections of the Galaxy and eventually the Galaxy as a whole.

With high-quality inter-probe communication this system should, after a great length of time, have explored the whole Galaxy and be in a position to send new probes to emerging stars as well as to the Magellanic Clouds and other extragalactic clusters of stars.

This is the von Neumann spaceprobe strategy as viewed from the human point of view. We know that we would like to explore the Galaxy. We may well decide to do it in this manner or we may not. The important point is that, as far as the ETI is concerned, the von Neumann probe is a more likely strategy for encounter.

My feelings are that it would be very surprising if we had not been visited by a system in some respects similar to this. Indeed, if the profusion of 'civilisations' which have possibly come into existence

since the birth of the Galaxy some fifteen billion years ago is anything like that which the CETI investigators believe, then there may well be several systems in our vicinity – and active ones at that!

Beings, or a being, responsible for satisfying their interstellar urges in this way will not necessarily be interested in CETI. In fact, the von Neumann-type spaceprobe would be of value in CETI terms only to a civilisation which was much more patient than our own appears to be. The length of time which would be needed to set up transmitters in the star systems within, say, one hundred light years of the point of the probes' origin is much longer than that needed to investigate the same number by radio (either 'radar' or simply conventional listening techniques).

If von Neumann-type probes have been entering our system the 'lifetime of civilisations' condition which should interest us is different from that used in conventional CETI equations. (The most interesting type of probe is going to be an active one. Only a functional probe can respond to a systematic search, and it will be much easier for us to detect a responsive artefact than a dead or totally uninterested/passive one.) The factors which affect this are, then, the average number of years between civilisations adopting this strategy, the proportion of such explorations which make a successful sweep of the entire Galaxy (and thus enter the Solar System), and finally the average length of time probes or their descendants remain active in the target systems.

An interesting point here – particularly with a view to our educating ourselves in the finer points, or even the basics, of CETI proper – lies in the possiblity mentioned above that probes from differing systems may coexist in one target area. Although we cannot assume that they would be even remotely interested in one another it is exciting to speculate what the results would be if they were.

Such a situation could bring about one of the great clichés of science fiction – the *Encyclopedia Galactica*.[8] Let us imagine that, over the billions of years Advanced Mental Life has been appearing and perhaps disappearing in our Galaxy, there have been a few encounters between von Neumann probes (vN) interested in an interchange of information. The data which they would then compile would illuminate the different outlooks and different psychologies behind the construction of the probes.

In this situation there would be some higher degree of correspondence. Both of the ETIs responsible for building these probes would have certain areas of their mental life aligned if their probes, which they designed and programmed, elected to follow

this common course. The first and most obvious factor which they should have in common would be the use of this particular strategy to satisfy their interstellar motivation. Secondly, and for our purposes more importantly, they would be probes capable of being motivated to attempt CETI. As long as they or their descendants remained active, which may run into many millennia, they might be able to tackle the problems of communication between mental lifeforms at least on their own level. Nor need the communication attempts be worked on in only one star system. What we would have would be two areas of expansion overlapping to an increasing extent. In consequence, encounter between the probes will take place in more and more systems. If one species of probe has a system of information-exchange among its own members, the first encounter could be made known throughout the species as rapidly as relay permits. In this case each probe which decided to attempt CETI would begin searching its target system for evidence that a member of the other ETI species was present there. Even if none were present, there could still be theoretical work on CETI which the probe might do using data transmitted by other probes, several light years distant, too heavily loaded with immediate practical work to take it on themselves. The fact that such probes may be many light years distant from their peers is not a great barrier in this case. The probes working on CETI will have hundreds of years to tackle the immediate interaction with the other CETI-oriented probe species. Lifetimes may run into thousands of years for the various generations. They can afford a degree of patience which we humans cannot. Their clock is not the twirling Earth but the revolving Galaxy.

With the interaction between the two species taken as far as it can go there may then be an exchange of information in which the two, with their different significance bases for interpreting phenomena, will be able to enrich one another's picture of the Universe.

There is no way of projecting how long a community of von Neumann probes could exist in the Galaxy. If, for example, there was a local disaster in one target system which destroyed the 'factory' and 'monitors' there it would be a simple operation for a vN in a nearby system with which it had been exchanging information to dispatch aid in the form of an 'egg'-laying probe.

So far I have discussed the probe species as having lifetimes of some thousands of years, but in the above case lifetimes might well run into many millions, perhaps even tens of millions of years. If the probes were capable of some redesign, they might also improve their survival characteristics by producing carefully considered mutations.

Should an ETI adopt the vN strategy once every million years there is still a chance that two probe species might interact. The likelihood of two CETI-oriented probes interacting decreases with the average length of time between their appearance. However, even without effecting CETI, an exploratory probe species may have a large databank concerning the nature of life in the Universe after having observed numerous star systems over a period of some thousands of years, and this may well include studies of other AMLs.

If they exist long enough they may well have a highly developed ability to identify and track other ETI probes, not necessarily von Neumann in nature, as they approach their target system. In this case the original contact between the two CETI-oriented probes may well be initiated by the already on-station probe in the target system as it observes the new one entering.

One fact, although not a particularly significant one perhaps to the observing ETI probe, is that a great deal of energy is generally required if a probe is to be accelerated out of its home system to an interstellar escape velocity. Similarly, a great deal must be used to decelerate it into the target system. One strategy which has occurred to a number of mere humans is that we may try to detect the approach of probes entering our system. Although no ETI probe will have human-based programming it may use a strategy for probe detection. In this case an entering probe will encounter evidence for ETI in the target system should the vN already resident there try to contact it. These vNs will not be indigenous to the system but the entering probe will not be aware of this. If it is a comparatively primitive probe from a home system lacking a vN 'colony' this may precipitate some peculiar conclusions. The builders in the home system would receive quite a shock. In the Daedalus scenario it would be the equivalent of our having an ETI message relayed to us from a star system right on our doorstep, and the repercussions would be dramatic.

Various factors influence the way in which different species of von Neumann probes might interact with one another. The crucial ones, as I have mentioned above, are how often a species of probe appears in the Galaxy and how its reproductive programming governs the way it spreads. If species die out, or are deliberately closed down, after an average period of time which is less than the average period of time between their appearing, meetings would be very few indeed.

Another factor lies in the possibility that, if the probes are fairly flexible creations, capable not only of reproduction but of some

redesign, they themselves may be subject to a long-term developmental process akin to evolution. Their original creators, the beings who had the initial interstellar urge, would continue themselves to be subject to the evolutionary (or evolution-equivalent) processes which brought them into existence in the first place.

It has been pointed out that ETIs interested in radio communication may cease to be interested either in the subject of CETI or in using radio as they climb higher in their development. If the probes which they send out mutate in such a way that they perform their initial tasks with greater efficiency, then the problem of probe mutation is one which works in favour of CETI, in a CETI-oriented probe, and heightens the chances of both survival and communication. Should the probe design mutate in some way which is not concerned with increased efficiency there is a chance that some species will lose interest in CETI. Hopefully, this is balanced by the emergence of a mutated interest in it among probes not initially programmed to cater for the concept of ETI at all.

Now let us look at another extreme. What if the average lifetime of a probe species is a great deal longer than the average time lapse between new species appearing in the Galaxy, and if most species are interested in CETI to some degree?

Let me illustrate this with the possibility that it need take a species of von Neumann probes no more than three million years to saturate the Galaxy. If the average lifetime of a vN family about its target star is in the region of five million years then we have a rough total of some eight million years during which the species exists and a period of two million during which communication can take place between its most distant members. In this scenario there would of course be only ten such two-way communications between these distant relatives. However, the entire tribe would number around 120,000,000,000, or a minimum of one for every star in the Galaxy. They would be handling quite enough communication from the family members among their neighbouring stars to be little concerned with sending messages right across the Galaxy.

Let me now be madly optimistic and assume that one mental lifeform every 50,000 years adopts a von Neumann probe strategy with an interest in CETI. In this case, between the birth of one species and its demise 320 others will appear, of which the first 40 will share Galactic saturation with the first probe exploration.

There is no scientific basis for choosing the above figures;* they

*See Appendix 3.

merely represent a very optimistic scenario on my part for CETI. The ultimate in optimism, of course, is to believe that the quoted figure of one 'civilisation' emerging each ten years also applies to the eventual emergence of a von Neumann probe from that 'civilisation' and that even on the cosmological scale the probes, because of their reproductive capability, are virtually immortal.

Should ETI have appeared prior to the formation of the Solar System it means that a vN may have observed the entire history of our Sun and its entourage of planets, and that there could be as many as a million-plus 'dead' species in our vicinity. Of these, around one hundred thousand would have contributed to a vast body of knowledge about our immediate stellar and interplanetary environment.

If ETI interaction has been taking place for billions of years right on our astronomical doorstep we do not have to start searching among the stars for evidence of their existence. It seems fairly sound for us to assume that they are quite well informed of *our* existence. If they wish to communicate, their expertise in handling CETI problems will ensure a fairly sophisticated sequence of opening moves on their part.

So much, alas, for optimism. The reality is that we have no certain knowledge of anything concerning advanced mental life elsewhere. No ETI may *ever* adopt vN as a strategy for Galactic exploration and, even if they do, they may not be even remotely interested in CETI. It must be said, however, that the same applies to radio broadcasting/listening techniques: essentially the ETI is an unknown quantity. However, the important aspect about the vN strategy is that the concept is very broad-based. From our point of view it would be a Galactic exploration programme with, one hopes, a CETI factor of some nature incorporated. That is, if we ever built one – and of course we have to build only one.

The basic problem with the CETI scenario I am setting up is 'first catch your vN . . .' To take an extreme case, suppose the average vN totals some twenty thousand tons, arrives every decade and reproduces completely once every five hundred years or so. In this situation they have eaten up less than .002% of the Solar System's planetary mass so far, assuming they have been popping in regularly during the entire existence of the System. To complicate matters, they probably do not arrive so frequently, reproduce at a more leisurely pace and 'cannibalise' the defunct elements which are being replaced. It follows that their mass is not going to be of particular assistance in determining where they are, and certainly not in seeing them.

Accidentally overhearing their domestic communications is another unlikely factor. If two monitoring elements are corresponding they will know the subjects of their monitoring well enough, namely the components of the Solar System, to make sure that none of them wanders in the way. A vN devised by ourselves would probably incorporate some kind of central switching technique, like a telephone exchange for spaceprobes, and this would handle all non-emergency data traffic.

For all we know, they may even have tried to contact us and we have simply ignored them. On the other hand, why should they bother? Their makers had a higher standard of comparative capabilities than we currently have. To them we must be among the less highly developed mental lifeforms. Perhaps, if this is so, they will attempt to communicate only, if at all, when we activate our own vN.

Despite all these drawbacks I still think that searching for vNs in the Solar System is more readily justifiable than radio searches for interstellar communications. Let me explain why.

Assume for the sake of argument that over the next few hundred years Man's exploration of space is purely by means of robot probes to observe various elements within the Solar System, and that his CETI endeavour is literally channelled into the realms of the interstellar signal. If we do not hear anything over the first ten years the hypothesis is still not disproved: the signal may come during the next ten years. If we have heard nothing at the end of the first century some scientists will be having grave doubts about their original assumptions concerning the rates of emergent 'civilisations' in the Galaxy which reach the stage of radio communication. These doubts will grow, and greater revisions will be required if nothing is heard after five hundred years, and more so after five thousand. *But the absence of a signal has not disproved the original hypothesis because the signal might always arrive tomorrow.* We could go on squatting here on planet Earth, listening vainly forever and still not disprove it. There is no way of falsifying this proposition. It is the perfect example of an *ad hoc* hypothesis.

My CETI hypothesis, the vN hypothesis, is also *ad hoc* at present but within the coming years it should prove possible to disprove it by scouring the Solar System to establish the absence of the vN. Dare I suggest that we might try out the Lagrangian points in the Moon's orbit about Earth using a lunar orbiter and, down here, a directional radio transmitter?

At this particular juncture I would like to throw my contributions into the speculations regarding the possiblity of there being

a probe in the Lagrangian positions. There seems to be a great deal of muddy thinking taking place in this area. I hope I can make things a shade clearer and not darker still.

If we wish to set up a postulate regarding a probe in these positions, we must work within consistent references. A hypothetical situation must be shown to be false within the terms which it proposes. This has not been the case regarding the Lagrangian spaceprobe hypothesis. A recent theory has been put forward giving a natural explanation for Long-Delayed Echoes:[9] this, however, is not relevant. It is important to understand *why* it is not relevant. The existence of a spaceprobe does not *ipso facto* rule out a natural explanation for LDEs as there is no reason why natural and artificial phenomena cannot exist side by side. As a consequence, the postulate of there being an extraterrestrial probe out there cannot be 'explained away' in these terms. Explaining LDEs in natural terms is not a fruitful course of action regarding the spaceprobe hypothesis: it is concerned with natural phenomena only and is therefore useful (and perhaps extremely useful) to those who seek to know more about the physical characteristics of radio in the near-Earth environment. Such characteristics cannot disprove the proposition that there is a probe at one of the Trojan positions.

To do so we must tackle the hypothesis within the terms which it proposes. The most obvious strategy – and the most immediately difficult – is to send spaceprobes into those positions to give us detailed knowledge of them. It would be ironic if, after flying the multi-billion dollar Vikings to Mars in search of microbes (among other things, of course), we discovered that by sending little more than a TV camera-plus-transmitter 0.1% of the distance Viking travelled we found evidence of not merely life but advanced mental life.

Hit the Lagrange positions with radio signals. If no response comes to a wide variety of signal types over a few weeks or at most months simply pack up. The probe is either not interested, not functional, or simply not there. In any event the proposition that a radio-contactable probe was hanging about at those points just fell over.

The overriding virtue of the experiment is that it is astoundingly cheap.

Should vNs be here, the factory elements are probably in the asteroid belt, somewhere in the vicinity of Jupiter or perhaps fairly close to the Sun. The latter could act as a kind of massive catcher's mitt for an incoming probe: the wind of electrically charged particles

issuing from our star might be used for some form of magnetic braking. This would possibly result in an orbit close to the Sun, from which the factory 'egg' might mine its materials.

Perhaps they might take up residence on comets, doing a sweep of the system every few decades to check up on their interplanetary progeny. Then again, a suitably altered asteroid, engine fitted, might coast and cruise among the planets as a supply-cum-factory vessel.

The possibilities are quite intriguing.

9 – Unbelievably Fatuous Observations

Within the terms of the vN hypothesis it is tempting to assume that certain probes might manufacture small monitor vehicles with atmospheric capabilities which could observe planets very closely. (UFOs!) On the other hand, the vN hypothesis is sufficiently *ad hoc* as it stands without encumbering it with any further paraphernalia. UFOs are certainly phenomena eminently worthy of investigation. The propositions that they are extraterrestrial vehicles, or terrestrial time-machines from the future, or disembodied intelligences from other worlds/dimensions, etc., etc., are great fun and earn some people a good deal of money, but how useful are they? There appears to be a great deal of imagination at work here and very little insight.

As a classification of most UFO reports my own listings are rather different from Dr Hynek's.[1]

First Kind: misinterpretation of natural phenomena such as planets, stars, the Moon, meteors, clouds, birds, freak reflections, 'mirage'-producing temperature inversion layers, freak electrical discharges in the atmosphere, fireball-plasmoids, etc.

Second Kind: misinterpretation of artificial phenomena such as aircraft, balloons, fireworks, flares, spotlights, satellites, even ground and sea transport viewed at night in unfamiliar terrain.

Third Kind: conscious deliberate trickery either on the part of someone who wishes to convince others that he or she has experienced a 'close encounter', or someone wishing to convince others that they are experiencing or have experienced one; honest mistaken belief by individuals that they have experienced something which they have not.

There can, of course, be a combination of many of the elements listed above to convince people that they are witnessing an extraterrestrial visitation. The most convincing UFO reports may be those containing such a combination. The fact of UFOs being reported is indisputable as is the fact that by far the majority of these reports is satisfactorily explained. UFOs which remain totally unexplained are *ipso facto* unidentified. This means that it has

been impossible to identify them as anything – including spaceships.

No one with an iota of wonder would doubt that our experience is full of indications that the Universe is a very weird place. What we must be wary of doing is placing preassessed interpretations on the various weird occurrences. The approach which I would like from a ufologist (*sic*) is a more critical one. Should a statement be made concerning ways in which I or anyone else could set about *disproving* the proposition that UFOs are spaceships I, at least, would be very interested.

There is always the possibility that some UFOs are of artificial non-human origins. It niggles away in the attic of my mind but there is nothing useful that it says to me about CETI; in consequence, I let it niggle on up there among all the other *ad hoc* hypotheses which I only let out on the strict understanding that they are going to behave themselves. As soon as bright coloured lights start sweeping across Arizona playing music scored by John Williams I am going to look very foolish indeed.

So is there anything useful which we can abstract from the contents of the whole Flying Saucer bandwaggon? Certainly there is nothing that is going to throw up insights into the nature of the ETI. On the other hand, what about the nature of mankind?

There is a wide and commercially well exploited willingness to believe in ETI on the part of the public. If tomorrow I decide to write a supposedly autobiographical book entitled *My Experiences Amongst the Saucerians* (under a pseudonym, naturally) and passed it to an unscrupulous literary agent (not my current one, naturally) who in turn passed it on to an unscrupulous publisher (not my current one, naturally) the chances are fair that we would all make a fortune! The public has a staggering willingness to believe in the most exotic propositions. Witness the response to spiritualism, to religious 'manifestations', religious cults, ghosts, fairies and extrasensory perception.[2] It is not necessary to either believe or disbelieve in any, all or none of these to appreciate how interested the public is in the exotic.

Like UFOs these phenomena are accompanied by the usual camp-following types of evidence – masses of reliable eye-witness reports, press coverage, elaborate theories and photographs which cannot be proved to be fakes. (Interestingly enough, the best example of photographic evidence applies not to UFOs or ghosts but to fairies.[3])

There would appear to be some form of psychological mechanism working in the mind of the human being which predisposes

us not only to believe in the exotic but to interpret non-exotic happenings in exotic terms. A fireball, for example, could be seen as an angel, a UFO, a demon, a ghost (or spirit), a psychic or an extrasensory manifestation depending on which exotic mechanism was operating on or within the perceiving apparatus at the moment of perception.

One of the more interesting experiments performed to highlight this activity was done within the context of UFOs. Under hypnosis and monitored by a polygraph 'lie detector' some people who did not claim to have any experiences with UFOs 'truthfully' described in detail their meetings with beings from other worlds in strange spacecraft which had picked them up.[4] Should this prove to be the case generally then either most of us have been subjected to saucer scrutiny, the memory of which has been hypnotically suppressed by the naughty little ETIs, or there is indeed some exotic-oriented mechanism at work within the human mind. If the latter is so, then we find ourselves close by if not actually in the area of speculation regarding flying saucers which Carl Jung[5] suggests is the important one. Jung sees the circular and ellipsoidal lights as symbolic of a desire for 'wholeness', and maintains that this symbolism is consistent with that found in the world's religions.

This has been followed up by a number of psychologists who see in UFOs a subconscious attempt to fill the space created in Western Man's psyche by the destruction of religious belief. Interestingly, a great deal of the literature on UFOs, more particularly among the sensational 'down-market' works, concentrates on the superior nature of the ETIs, who are almost exclusively human in form. They are not only our technological betters, but our moral ones as well.

Something as fundamental as this within the nature of ourselves has bothered a number of those who have dwelt on the possible consequences of CETI. It bothers me, too. I am even bothered about those who are bothered about it. Let me explain. There is the 'Zealot' who wishes us to reject the whole idea of CETI and tells us not to answer the space 'phone when it starts ringing. Such individuals fear the consequences. Their fears are rationalised by reference to historical analogy but perhaps are really rooted in the exotic-orientation mechanism. Is their fear really rooted in the fear which we might all feel at the prospect of coming face to face with God? This is the obverse of the awe-wonder-and-love side of the exotic coin, and is every bit as much a 'gut' reaction as the other.

The possibility that such extreme reactions could cause chaos in the event of encounter is often borne in mind by those who wish to

discuss encounter's consequences. There is some considerable bulk of opinion that, should the existence of ETI become an established fact, it should not be released to the public as the reaction could be outwith the ability of government to control. The old diehard illustration of this is Orson Welles' broadcast of *War of the Worlds* in 1938. The response to this was one of mass panic and it is seen as indicative of what could happen in the event of a real encounter. A friend of mine once said that news released of any kind of encounter would produce mass hysteria on a global scale.

One of the main problems these people see is the fact that so many of us already believe in the ETI and have a great deal of subsconscious emotional capital invested there. I would venture a personal speculation here. An aspect of the flying-saucer days of the early 'fifties that tends to be overlooked by those who comb the newspapers of the time, particularly the American newspapers, for reports is this: what was happening on page one?

The atmosphere in these early formative years of UFO investigation by government agencies was a heavily charged political one. It is interesting to use it as a reference when starting the task of evaluating Projects Blue Book, Grudge and Sign. These took their investigative attitudes from an administration which grew increasingly paranoid as the Cold War chills ran up the spines of Americans both in and out of politics and which continued to shiver for over a decade.

The possibility of subversive agents using a widespread UFO hoax to spread a *War of the Worlds*-type panic and create an hysteria which could cloud the nation's appreciation of, and response to, a genuine Soviet threat was a serious consideration. In December 1952 the CIA was ordered to organise a meeting of several august figures to review the UFO problem under the chairmanship of the physicist H. P. Robertson. They met from January 14th to the 18th 1953 and amongst their conclusions was the following:

> 'That the continued emphasis on the reporting of these phenomena does, in these parlous times, result in a threat to the orderly functioning of the protective organs of the body politic. We cite as examples the clogging of channels of communication by irrelevant reports, the danger of being led by continuous false alarms to ignore real indications of hostile action, and the cultivation of a morbid national psychology in which skillful hostile propaganda could induce hysterical behaviour and harmful distrust of duly constituted authority'.

Amongst other things it recommended that:

> 'The national security agencies institute policies of intelligence, training, and public education designed to prepare the material defences and the morale of the country to recognise most promptly and to react most effectively to true indications of hostile intent or action'.

Evidently UFOs were regarded as a potentially effective element in some kind of psychological warfare which might be waged on the American public prior to Soviet intrusion into North American airspace. Did the CIA test this supposition? Did they or the FBI expose the public to mock UFOs? Did they even expose the Soviet public to mock UFOs?

This is not the place to speculate on what Soviet UFO reports may or may not have been exercises (if they ever took place at all) in which Western Intelligence agencies tried out the principles of UFO hoaxing. Anyone who wishes to inquire in this area is not going to be given a great deal of help. Although some aspects of Soviet UFO reportage have been made available in the West, there is nothing like the requisite depth of domestic documentation now available in the USA, for example.

What the security agencies may be sitting so embarrassedly upon could prove to be the fact that they are indeed involved in ufology. But problems may be due first of all to the very fact that they do not wish dumb (but increasingly suspicious) Joe Public to realise that they are interested in discrediting UFO reports only for security reasons. I would be quite ready to accept as an explanation of certain UFO close encounters a statement detailing how they were set up as psychological test runs of public credulity by agencies responsible for national security. Not an easy thing to admit to taxpayers on whom the tests were run, who provide the funds from which the same agencies receive their appropriations. Some people, some in high places, too, would look very egg-faced indeed.

There may, of course, have been occasions on which the public attitude of ridicule to UFOs became quite useful. Let me illustrate this by outlining my own interpretation of the famous sighting of a 'craft' and its 'occupants' outside the town of Socorro on the 24th of April 1964.

Deputy Marshal Lonnie Zamora was pursuing a vehicle south from the town along US Highway 85 when he spotted a metallic egg-shaped UFO cutting across his path and travelling roughly west-by-south. It vanished behind some high ground to his right and, abandoning his pursuit, Zamora turned and went after it.

The terrain was rough but about a minute later he caught sight of it again. This time it was on the ground with two small figures in coveralls beside it. He watched them for a couple of seconds before his car went into a dip and lost visual contact. A half-minute or so later he pulled up atop a slope and started to climb out when he heard two loud slams. Then, looking into the ravine, he saw the object and noticed a curious symbol on its side:

Suddenly a blue flame shot out from below it and the UFO roared up into the air. Zamora sprinted away from it and wisely threw himself face down, feeling the heat from the flame as the object rose from the ravine. The noise stopped and he watched it fly off, and eventually disappear in roughly the same direction it had been moving before.

This is very heady stuff. Ray Stanford's splendidly detailed book *Socorro Saucer* is an intriguing account of that author's personal investigation of the events there. Reading it, I was left with the impression that he was satisfied that something extraordinarily outwith human experience took place:

> that what he calls the 'versatile and highly sophisticated craft' was a non-human flying vehicle and possibly extraterrestrial in nature.

There is however another possibility which has not, to my knowledge, been mooted and one which deliberately uses the UFO story as a cover.

In my opinion what Lonnie Zamora saw was an RPV not a UFO. Remotely Piloted Vehicles, or RPVs, are a peculiarly exotic form of radio-controlled aircraft. They were originally designed as targets for manned fighters and other weapon systems. But during the 1950s another line of development took off, using RPVs to send back television pictures. This has an obvious advantage in battle. Being relatively small, sneaky and quiet, an RPV carrying TV equipment can reconnoitre the lie of the land more readily than a Jeep or a helicopter and has the advantage that if it is blown apart the 'crew' remains unscathed being several dozen miles away.

So did Deputy Marshal Zamora intrude on a field-trial of one such machine and spotted a couple of Army technicians crouching beside it to fit a fresh launch-bottle to the underside? The curious

symbol on the hull possibly indicated a service hatch for the telemetry equipment. The two slams which he heard would then have been the doors closing as the two technicians climbed into their car and hit the launch-button (from the map in Ray Stanford's book they could have possibly parked on the ravine floor in a position to the right of Zamora as he looked at the object). Then they hit the launch-button giving the policeman only a moment to observe it before it leaped upwards, launch-bottles ablaze. The technicians' vehicle would make good its retreat behind the boom of the lift-off.

Lonnie Zamora did not claim to have seen a propellor, and RPVs are usually prop-driven, but then he had virtually no time to notice anything but the general shape and the symbol before it blasted off. Once aloft with the rocket cut out, the quiet fast-spinning prop would have been virtually invisible.

Ray Stanford points out that another sighting of apparently the same object took place some twenty-five minutes earlier by a person in the Albuquerque area, a city of quarter-million or so inhabitants some seventy-five miles north of Socorro. To travel this distance in the time given the object would have been travelling at about the speed of a light aircraft. This is the speed one would expect from an RPV.

Another indication to the nature of the UFO comes from the family travelling north into the town who also saw it and mentioned the fact to the manager of a service station. They seemed to have believed that what they saw was a strange aircraft. This is significant because, unlike Lonnie Zamora, they could not be expected to be trained objective observers. The police officer reported what he was able to observe but, apart from the object's final silent departure, he did not have his eyes on it for more than a few seconds at a time and never came closer to it than fifty feet. The people in the car, however, complained that it almost took the roof off their car. But even as untrained observers they identified it as an aircraft and clearly thought that it was some peculiar form of aircraft which was in trouble and being forced into an emergency landing. They said nothing about UFOs or Flying Saucers which is precisely what anyone might expect from an untrained observer. They not only would seem to have come closer to it but to have been travelling in a direction from which to observe it more favourably and possibly for a longer period than did Lonnie Zamora. Furthermore, there were five of them and their impression was that the aircraft seemed slightly longer than the car they were travelling in.

In his book Ray Stanford claims to have seen a similar object six days after the main incident. He says that at 10.22 am on the 30th of April he saw a 'fairly large' cigar-shaped object moving rapidly across the sky, the speed being in his estimate several thousands of miles per hour. He bases this on clouds which obscured the UFO and the fact that other observers several miles ahead of him in a seemingly favourable position to sight it saw nothing and thus it must have been high above or behind them.

Could he have seen an RPV? He watched it for about two minutes during which time it travelled from dead-ahead through 85°. Now if this was a large object, say around the size of a Jumbo jet, it would certainly have to have been zipping through the sky at around Mach 3 to fulfill his described conditions. But curiously enough an RPV would fulfill them too.

An RPV about fifteen feet long, travelling at 180 mph and 2,800 feet distant at an altitude of around 1,000 feet would have looked more or less the same. To other observers several miles away it would simply be too small to be significant.

What clinches this identification for me is the fact that Ray Stanford twice reports suspicious vehicles in his account. During his own sighting, a Jeep, which he points out was travelling so that the occupants could scarcely not have noticed the object, passed him from behind. The day before he was at the landing site when a new model Ford sporting a remarkable radio antenna appeared. Glancing at the occupant Stanford noticed that he was peering off to the east, the direction from which the object had approached five days earlier. To me it seems reasonable that these vehicles were involved in the RPV evaluation tests.

This brings us to the point at which deliberate misdirection must have taken place, indeed had to take place as a simple matter of policy. The spokesman for White Sands testing range, Captain Richard T. Holder, is described as 'up-range commander' but elsewhere in the book Stanford mentions an Army intelligence officer who can only be Holder. Frankly I would guess that neither description is strictly accurate and that Captain Holder was *de facto* a representative of the US Army Security Agency in this matter. As such it would be part of his remit to ensure that security around the testing of, say for example the Northop NV–104 RPV which was being evaluated by the Army in 1964, was secure. He was certainly not liable to tell any UFO investigators that they were really on the fringes of exposing secret RPV evaluation tests.

In fact, the entire UFO interest in the matter would seem to have been a fortuitous cover for these tests. The aura of 'crankiness'

which had been deliberately fostered by fiat of the Robertson Panel could thus be safely exploited.

Interestingly, this attitude seems quite prevalent in the English-language countries. The curious aspect of this is that when we travel beyond these areas we frequently meet with attitudes which are strikingly different. In Britain or America, until fairly recently, no respectable journalist would have dared air a belief in UFOs. The idea that government ministers or serving members of the military would do this is still rather unlikely. In France, however, OVNI (as 'UFOs' translates into French) is a quite respectable topic for serious discussion. In 1977 the French Army's official magazine featured an article by one of the country's most widely respected TV journalists, Jean-Claude Bourret.[8] He reported on an increasing incidence of OVNI sightings. He quoted Colonel Gaston Alexis, M Robert Galley (Minister for the Armed Forces), M Cochard (Director of the National Gendarmerie) and astrophysicist Pierre Guerin, a senior research member of the French National Centre for Space Research. A similar line-up of status-holding individuals by a status-holding individual being quoted on UFOs in an official military magazine in the English-speaking world would have been virtually impossible. Had it somehow been made possible, the attitude would have been absolutely the opposite of the French one: it would have been firmly dismissive of the phenomena as one unworthy of investigation.

At this point let me say again for the record, that UFOs *are* in my opinion worthy of investigation. Stating that many of them are simply plasmoids or temperature-inversion mirages is unsatisfactory. To be demonstrated as viable descriptions of the otherwise inexplicable phenomena these conditions should be understood, and they are neither of them well understood. Certain UFO sightings have all the hallmarks of a plasmoid or inversion-layer, but the theoretical conditions needed to satisfy applying them as explanations are not present. Investigation can only increase our knowledge of the world we live in.

Let me put another hypothesis forward here. There are, at the time of writing, reports of increasing numbers of sightings around airports (often military) and North Sea oil rigs.[9] I cannot help but speculate that perhaps the increasing communications traffic in the short-wavelength (high-frequency) areas of the electromagnetic spectrum may be associated with their appearance. Microwaves are effective in beaming energy from point A to point B, as has been demonstrated widely. Dr Glaser's proposals for shunting it down from orbital power stations in this form[10] and the increasingly

common microwave oven in the kitchen are two examples. What effects would a freak focussing event have on the atmosphere around the focal point? Would normal but heavy traffic have particular energy interactions in as yet undefined atmospheric conditions? From a purely scientific point of view the subject seems worthy of investigation.

If it turns out that some UFOs are of ETI origin, whether spaceships flown by small green people or atmospheric probes sent out by larger robot interstellar probes, I will be the first to stand up and shout: 'I was wrong and being wrong's terrific!' Let me look foolish if genuine hoaxers have been at work; scepticism can be taken only so far. There is an immense popular following for writers of UFO books and for science fiction. The media's general cynicism for the subject may act as a buffer, but depending on how a hoax was perpetrated there may be many members of the public only too ready to believe and respond positively to it.

Whether or not agencies have quietly campaigned to make UFOs a subject fit only for ridicule, up until very recently ridicule was the official attitude. It was an attitude which tainted the whole of CETI in many eyes. Anyone taking a serious interest in advanced mental life elsewhere was regarded as a bit of a nut. This is probably why the early CETI conferences were not particularly interested in publicity.

In the event of an actual encounter, dismissiveness is, of course, the most dangerous attitude to hold. The shock which the event would have on not merely an unprepared psyche, but one which was antipathetic to the concept of ETI, might be, at least initially, quite damaging.

The problem is that UFOs and CETI seem to be synonymous in the public mind. This equation should be dispelled if for no other reason than that the attitude towards UFOs tends to be either uncritical acceptance of extraterrestrial origins or, as mentioned above, ridicule. A belief that UFOs come from outer space has a concomitant belief that intelligent life exists elsewhere, but a belief that intelligent life exists elsewhere does not imply an acceptance of UFOs as being extraterrestrial in origin.

In other words, the Viking results (which I interpret as indicative that life or something close to it exists on Mars[11]) do not mean that flying saucers come from the red planet. This kind of thinking, speculative but always critical, is the best frame of mind to adopt with regard to the whole subject of CETI. It is the kind of attitude which I and others interested in the problems which it creates often strive for. Unfortunately, in too much CETI thinking, probably my

own included, there is a lack of imagination behind both the speculation and the criticism.

10 – Them

One afternoon on glancing through my local newspaper I noticed that there were two science-fiction movies on in the one cinema complex, *Star Wars* and *Close Encounters of the Third Kind*. Being a movie gourmand, particularly an SF movie gourmand, I decided to spend the day gorging myself on both. With mind suitably cranked into 'gee-whiz' mode I settled down for a five-hour stint before the giant screen. A profusion of dazzling lights and giant-laser-blasting spaceships later, I emerged pleasantly stunned and grinning into the teeming streets of Friday-night Glasgow.

This is not the place for movie criticism and I am no student of the cinema, but I enjoyed those offerings immensely. Nor was I alone in this. The box office receipts for both films are now part of cinema legend. They were followed by a profusion of bandwagon-mounted products, few of which had either the daring or the originality of these two front-runners.

What was of particular interest was the attitude to ETI in the presentation of these fantasies. Neither of them made any great impression on me, although I was not disappointed. Both were very terrestrial in their conception. *Star Wars'* ETIs even knocked back the booze together in the local cantina. The behaviour of the *Close Encounters* creatures was slightly less common and even hinted at non-human reasoning, but sadly they turned out to be Little (Very Pale) Green Men.

The finest examples of ETIs in the cinema must be in *Solaris* and *2001: A Space Odyssey*. *Solaris* is in fact about the problems of men on another world with a sentient ocean. The two widely differing sentient lifeforms vainly attempt communication with each other. In *2001* the ETIs never appear, only their works and their power are in evidence. Both movies point to real possibilities. *Solaris* indicates that on other worlds evolution may have taken a different route from that adopted here on Earth; in this instance the profusion of organisms found on Earth is represented by the immense complexities within the structures of the ocean itself.

These movies are more than just good SF movies, they are examples of SF at its finest. When it is operating well, SF is philosophical fiction, and herein lies a great deal of its appeal. There has been much made of the escapism factor in SF, too much: there is more escapism in the average spy thriller because, *not* in spite, of the

fact that it allows the reader/viewer to escape into a fantasy world within his or her own real world.

The amateur philosopher is generally unschooled in philosophy, believes it to be an obscure academic discipline and is unaware of the fact that he or she indulges in it frequently. Virtually all SF fans when they meet and discuss the subject compare concepts of time and space which, if not as sophisticated as those tackled by the professionals, are at least as wide-ranging.

The discussions which followed the first showing of *2001* in Glasgow were among the most stimulating I have heard. Unfortunately, the fact that *Solaris* was sub-titled and screened at our local arty cinema precluded the possibility of there being similar discussions. What emerged quite clearly was that there is a great number of people who are readily prepared to accept the possibility that other mental lifeforms can be even more different from us than we can presently imagine.

Perhaps this is why the concept of the amorphous being portrayed in Fred Hoyle's *The Black Cloud* became widely known in the field of CETI. As an example of SF it is first class and carries the seal of academic approval, having been written by an established scientist of impeccable, if controversial, reputation. How many scientists would have referred to it as it originally stood, an idea which was once tossed around by Thomas Gold? In the form of a novel it attained general currency. Nobody should think that this made it the province solely of the scientifically minded. No SF should ever be that.

In fact, it is possible to find examples of almost all the differing forms of possible biochemistry imaginable in the SF books and stories which have been turned out over the past few decades. In the works of one writer alone, James White, can be found a vast profusion of beings in a set of tales ('Sector General') based around an interstellar hospital.[1] These range from amoebic blobs, to insectiles, to chlorine breathers with weird and wonderful behaviour patterns.

The possible biochemistries for life elsewhere appear limited from our point of view, but then our point of view is limited by our knowledge of chemistry. We cannot state what all the reactions of all possible elements and compounds will be in relation to one another under every conceivable permutation of physical conditions. As a consequence of this, we tend to be, as Carl Sagan would put it, oxygen chauvinists. Let us take a brief glance at what a few of the alternative chemistries might be.

A great deal of water slops around inside us. We are virtually fish

which migrated landwards, carrying with us our own oceans inside our skins. There is good reason for this. Water is an ionising solvent: not only does it dissolve things, it also encourages them to form ions, which readily combine with other appropriate ions. Water also has a kind of handling mechanism in the form of loose hydrogen 'bonds': these hold the water together in strings and nets of molecules and are ever changing their configuration. This is useful. The loose bonds also set up conditions for biochemical activity to take place and are particularly important in aiding and abetting the genetic hocus pocus that goes on deep down in the cell.

That is what water does, but perhaps there are other equally useful properties in other liquids. Ammonia is one which both J. B. S. Haldane and V. A. Firsoff have considered. P. H. A. Sneath[2] mentions the possibility of still more, such as hydrogen fluoride, hydrogen sulphide, and even hydrogen cyanide. Creatures developed within the chemistries of these compounds would, of course, regard Earth as a highly unlikely abode for living beings, it being strongly polluted by that highly inflammable, corrosive and poisonous substance oxygen!

Carbon is one of the basic building-blocks of all known life, but here again there is the possibility of another approach which would be successful for life attempting to develop in a carbon-poor environment. There are substitutes or at least analogues for carbon to be found in the table of elements. Silicon, for example, is a particular favourite of the SF writer: sluggish stone-like silicate beings scrunching away at rocks and excreting gravel have been making their lugubrious ways through SF since the days of Stanley G. Weinbaum's pyramid creature in his 1934 classic *A Martian Odyssey*. It has now gone out of fashion as an alternative chemistry but perhaps new knowledge will bring new possibilities, as it could to germanium, another analogue of carbon.

At very cool temperatures the so called 'noble' gases, which are generally fairly inert, actually form compounds. In contrast, sulphur might act as a vital solvent at really high temperatures as Hal Clement suggested in his novel *Iceworld* (the title planet being Earth).

Given a planetary environment which is different from that with which we are so very familiar we should expect that, across the thousands of millions of years of the planet's existence, there are liable to be some chemical peculiarities arising. We should not assume that these will necessarily lead to life of any sort but they may lead to some very exotic conditions.

There may be no life on Mars, for example. The results from the

Viking landers' biological labs proved to be ambiguous. If there is no life, then the chemistry of the Martian soil is odd indeed. This in no way contradicts what we have learned about the Universe over the past few millennia. We have come to expect the unexpected. In particular, we have over the past century come to regard the apparently inexplicable or paradoxical as being the norm. A problem is only a real problem when its solution creates further problems.

We must expect bizarre chemical and biochemical activities to be present in other parts of the Universe. By their very nature we cannot confidently predict what they are likely to be. As a consequence of this, we should be very wary of predicting what course of increasing complexity evolves therefrom. Using the rise of life on Earth as a stereotype is all very well if you are painting your picture with a really broad brush on a very coarse canvas.

What is really not viable is any attempt at drawing analogies between the rise of intelligent life on this planet and its putative rise elsewhere. It is fair to say that the evidence for chemical evolution indicates that complex chemical phenomena may produce chemical systems elsewhere, which, if we could examine them, we would eventually decide to describe as *bio*chemical. How the lifeforms would change and develop from that point forth we are in no position to say, but we do have an indicator as to one factor – it will almost certainly be in many respects profoundly different from anything which we have come to imagine.

There has been a fair amount of very penetrating inquiry into both the nature and the evolution of intelligence. Some writers and CETI specialists freely apply this to the 'Extraterrestrial Civilisations' to which they frequently refer. I must reiterate that I find this to be the most staggering conceit anywhere in the numerous volumes devoted to the topic. My own suspicion is that, if we are ever to come to terms with an ETI, we must regard the concept of intelligence as a very plastic one.

What then can we say about advanced mental life in SETI/CETI terms? First of all, by virtue of the fact that it is alive it is an information store; secondly, it uses its information in such a way that it adds to it; thirdly, it has as its basic expression of that information a relationship between itself and its environment; fourthly, and finally, an expression of that relationship is an interstellar urge (or we wouldn't be encountering it).

The axiomatic bases for an AML's mathematics may therefore be not merely different from our own, but the being may not even be aware of the functioning of its 'mathematical' faculty in the same

way that we are. Processes like logic and mathematics may run at a subconscious level for beings with a powerful, wide-ranging computational faculty at the very foundations of their mental development; concepts such as zero and infinity might mean little to them, particularly if the physical configuration which gives them this faculty is distinctly different from the human brain.

Samuel Aronoff has pointed out that social evolution is the partitioning of information and response processes within a species. In the case of a non-terrestrial AML, the selective pressures on how such partitioning comes about are liable to be different in a number of respects from those on Earth, which have been operating generally within the history of Earth's environment. This very probably being the case, what we must look to is not social evolution among our fellow inhabitants of the Universe but a great variety of mutually exotic processes each to some extent analogues of the other.

Joseph Royce, who has devoted a great deal of his professional life as theoretical psychologist to the proposition that we, as human individuals, are encapsulated within a particular way of knowing, believes that there could exist alien 'world views' which would have a tremendous impact upon our own.[3] He sees us as a limited, partly genetically, to epistemic encapsulation. Our consciousness is a product of three factors: reason, symbolism and perception. R (Reason) + S(Symbolism) + P(Perception) = Human consciousness. The mechanisms which support these factors may differ from AML to AML. Indeed, the factors which dominate the mentality of an AML may not even be closely allied to any of the three which are essential to our own. In another AML there could be at least one X factor which could combine with or substitute for R, S or P in ourselves, or even supplant them entirely, which would give us combinations such as *RSPX*, *RSX*, *RXP*, *XXP*, *SXX* or even ultimately *XXX*. The latter would be by far the most difficult beings to face intellectually. Imagine something which we saw as a really sophisticated 'technological culture', a 'being' which had totally alien ways of perceiving the Universe, did not interrelate symbols in the way which we do, and had fundamentally different bases for its thought processes particularly in areas we explore with logic and mathematics. If, on top of this, it was principally involved in intraspecific communication by something akin to telepathy, we would be in a position where contact of a meaningful nature was virtually impossible.

We should come to the conclusion now that there are possibly more interpretations of the Universe than merely the human one.

Beings evolving differently (we may not even view their developmental history as true evolution in our terms, in fact) are likely to have a separate 'angular truth' from ourselves.[4] Try to envisage advanced mental life, including ourselves and the cetaceans on planet Earth, as having mentalities shaped like tennis rackets without handles. They are limited in their physical structures. They have differing 'diameters' and 'mesh sizes' and are arrayed at different angles to one another. To take this wild image into wilder territory you must imagine the Universe around them as a torrent of tennis balls all zooming in different directions, all travelling at different speeds and no two of the same size. Any racket can interact with any tennis ball travelling in such a manner that it will come within the boundaries of the racket. The problems arise where, in the first place, the balls are smaller than the mesh size, in which case many of them are liable to pass through without reacting – some small ones will, of course, hit the mesh as a matter of probability. The second problem is with balls which are travelling at a very shallow angle to the racket, as these are likely to zoom past (as are those coming in a steep angle but outwith the dimensions of the racket).

Holding this rather strained figurative description of AML in the imagination, we can try to express SETI and CETI as attempts to draw together two rackets. If we succeed, the difference between ourselves and the other AML will be principally angular: the areas of clearest correspondence will be concerned with the tennis balls which interact with both of us at the same angle. The greater the difference in angle the more difficult becomes the possibility of exchange, but the greater becomes the possibility of breaking out of our 'epistemic capsule'.

If the analogy holds true then it should be possible for both ourselves and non-human AMLs to enrich our views of the Universe, including our views of ourselves. This enrichment may well lead to new methods of approach to the problems of CETI and perhaps even to the creation of translator beings, whose mental structures can encompass the singularities of the two 'parent AMLs'.

Should this ever come about, we may find ourselves having to contend with areas which we literally do not have the requisite equipment to tackle properly. To examine this means plunging into the area of the unbelievably fatuous hypothesis. Well, with fair warning given, I am about to splash into these waters.

Let me examine a purely speculative hypothesis which I am not going to put forward as anything other than fantasy. It is rightfully

placed within these pages only as an illustration of how different our abilities may be from those other creatures out in the Galaxy.

I want you to consider the possiblity that supernatural phenomena are attempts at CETI by beings with a very different mental structure from our own. This accordingly has different functions, the principal one of which interacts with the Universe in what we would describe as psychic terms. In this scenario ghost phenomena would be 'replays' of events picked up by the ETIs, and rebroadcast to us in much the same way as some scientists imagine that the first signs of radio contact from another star system might be us hearing replays of 1930s radio programmes, beamed back at us to catch our attention.

Let us assume that there really is a psychic energy phenomenon associated with all living beings. Then we should also assume that that energy can be transmitted in some manner which the ETI can appreciate. Perhaps the moment of death discharges a great deal of information in this psychic form from the dying organism, either directly about itself or about certain events in its life. What happens on rebroadcast is that information about the dead reappears in a variety of manifestations.

If this is the case, then either the psychical tennis balls interact with our mental tennis racket at an extremely shallow angle, so that we seldom strike them or only at the rim, or they are too small for our mesh to field consistently. In either case, we are partly aware that something is happening but because it is so inconsistent with our own mentality we cannot accommodate it.

This leads to a number of interesting speculations. Hypnotic subjects regressed beyond their own lifetimes have been known to produce evidence of 'previous lives'. Could reincarnation be psychical CETI? Likewise, could the old stories of heavens and hells merely have been crude attempts at conveying extraterrestrial environments to the human mind? Likewise demonic possession, vampirism and lycanthropy might be memories of ETIs coming across strongly, into what they did not realise was an environment which could handle the psychic aspects of their minds only minimally. Furthermore, concentrated psychic power, making use of psychic communication masers or lasers, being received by human beings who were as optimally tuned as was possible for a mere human would give those individuals apparently supernatural powers.

And, of course, if the psychic powers were operating outwith Einsteinian space-time they could provide psychical data about the future ...

Hopefully the general picture comes across from that reckless flight of fancy. It may be that ETIs are indeed trying to contact us but that we cannot appreciate their attempts for physical/technological or mental limitations on our part. To be realistic about the psychic potential we might say that a telepathic AML might attempt to embed images in our consciousness which it felt we would associate with CETI. Who knows, could this account for the numerous people who have under hypnosis proved to hold encounters with UFO inhabitants locked away in their subconscious minds unbeknownst to themselves?

To belabour the tennis-racket image, I want to point out that the whole picture is of billions of rackets – all shapes and sizes and with various mesh patterns and dimensions – arrayed in a random scatter of angles. Nor does it stop there. The picture is not static. It moves. The angles change at different rates as do the sizes and shapes of the rackets and their various meshes. New rackets continually appear among the old and all of them, like snowflakes, are quite singular: each is perfectly unique, each an exotic treasure of mysterious mentation.

11 – High Society

Many voices before mine have said that we are the only civilisation in the Galaxy. I add mine to the chorus but with a descant. In terms of what we conceive to be intelligence we may in fact be virtually alone in the Galaxy – if not the Universe. But in terms of powerful and profound mental life I at least feel certain that we are, as they say, not alone.

Enrico Fermi's paradox 'Where is everybody?'[1] is resolvable by demonstrating that there is no paradox. If AML has evolved over the billions of years of Galactic history at a fairly regular pace where are all the ETIs? If they are all different not merely from ourselves but from one another as mental lifeforms then we must define clearly what we are referring to in the 'body' part of 'everybody'. Are we not saying in effect: 'Where are all the spaceships, the colonists and evidences of interstellar exploration, conquest and empire?' Is this in effect our statement: 'Where are all the beings which think like us, have our picture of the Universe and our motivational drives?' There is therefore no paradox. They are all around us. We are 'everybody'.

For an AML of non-terrestrial origins the motives lying behind any interstellar urge which it may possess could be so different from ours that they could be literally inconceivable to human beings. Concepts such as 'conquest' and 'empire' are quite distinct from 'exploration' and 'knowledge', but both sets have a similar relationship and similar 'roots' – terrestrial life.

Should we ever encounter a radio CETI attempt from elsewhere or discover an extra-solar spaceprobe in our system we should accordingly be careful in our interpretation of the ETI's motives. Our interpretation of them might safely be that there is a principle of extension at work within the behaviour of the ETI. We cannot say other than that *with our terms of reference* it is probably exploratory.

How much advanced mental life is there likely to be out there anyway? The estimates vary comically so there is no point in talking about a count. Let us assume that we are very much the average. In this case, the average time for a given body of stars to produce an AML is our own five billion years. This means that half the number of AMLs which a group of stars is going to produce have already appeared at the end of five billion years. Taking a body of stars to be

analogous to a chunk of radioactive metal which pings out particles the way the stars ping out AMLs I am going to guesstimate that any body of stars has an AML 'halflife' of five billion years.

If this is so, it is fairly obvious that most of the Galaxy's present AML potential has been used up. This does, of course, depend on the rate of star formation; accordingly I am going to consider only the stars as old as or older than Sol. The first consignment which arrived some fifteen billion years ago should have now produced almost 90% of their AMLs, the middle-aged group a mere ten billion years old should have given rise to about 75%, and we are at 50%. Thus if we are average then the Galaxy to date has produced over 70% of its AMLs and we are arriving late in the race.

Let me now tackle star formation. It would appear that stars probably appeared more rapidly during the earlier eras of the Galaxy than at present. To balance this up, the stars now popping out of the interstellar nebulae tend to be richer in complex heavy elements. I will assume that the balance here is approximately justified for a fairly steady rate of AML appearance. This means that the *percentage* of produced AMLs is continuing to rise.

Who knows what the real numbers are? They may be billions or a few dozen but the assumption of mediocrity tends to put us in the picture when most of it has already been painted. This is no bad thing. Assuming that some form of CETI has been established (probably quite different from any we are currently fooling around with in the kindergarten), there is a likelihood that the Galactic Club of Ronald Bracewell[2] really does exist. An intercommunicating community of developing mental lifeforms may already be thriving in the stars around us.

There may in fact be a kind of reverse zoo hypothesis (the zoo hypothesis suggests that ETIs are watching us much as people watch animals in a zoo) whereby we have to wind our way down a tortuous intellectual, psychological and technological maze before we can even make ourselves known to these ETIs as beings significant in their own terms. This really will make it the toughest of all possible clubs to penetrate.

What happens then to the lifeforms who cannot make themselves heard no matter how hard they wallop the door? Do they form another club? Could there be a variety of clubs coexisting in the Galaxy within the same regions of space which are only dimly aware of each others' presence, if at all?

To gain entry to an exclusive club one is generally introduced by an established member. No amount of ringing the doorbell alone will suffice. Accordingly, what we must search out among the stars

is an AML which has 'racket' characteristics as close to our own as possible. This may prove to be quite a task. We may well find ourselves to all intents and purposes alone in the Galaxy for centuries if not millennia (although I have aired my doubts about the survival of us as *Homo sapiens* for more than a few more hundred years or so).

On reading Carl Sagan's *The Cosmic Connection*,[3] I was rather startled to find that the eminent scientist seems to regard the formation of a Galactic Club as a process of homogenisation. Quite apart from the fact that I view this prospect as appalling, I can hardly regard it as being credible. Even if the various AMLs in the Galaxy are not as disparate in nature as I believe them to be, the postulate that homogenisation can take place as a Galactic phenomenon is certainly slightly cross-eyed. Acculturation is a two-way process: to begin with, both or all of the interacting cultures change in response to one another; secondly, they continue to change in response to the responses of one another. On a small scale with good communication this can result in homogenisation, but the conditions must be kept stable.

To start small and work upwards I will begin in childhood. I was raised in a tenement with a dozen families living up the stairwell (or 'close', as we call it in Scotland). We had Catholics, Protestants and a Jewish family. Sometimes we all lived in stupefying harmony, occasionally it was bedlam, but always communications were first-rate. Heterogeneity as much as homogeneity was encouraged by this set-up. It was very easy to acquire some aspects of your neighbours' behaviour. It was equally easy to eschew that which you found distateful. To this day matzohs do nothing for me but gefilte fish are fine. The result was an ever-fluid heterogeneity.

The point was that, although we lived in a densely crowded local community, we had many channels of cultural or even subcultural access outwith it, as we lived in a city.

Damascus is the oldest surviving city on Earth. In spite of the fact that it has been around for some thirty-five centuries there is no sign that it is any more homogeneous a community than any other city of similar size in the world today. Furthermore, cities have always been loose amalgams of many differing kinds of people. They may have language and religion in common, but the variety of activities which go on in the myriad lives during a single day is vast, the personalities never duplicated, the opinions frequently conflicting and family customs and traditions differing from house to house. The city is too large for homogeneity.

The rural community does tend to homogeneity because there is

comparatively such a small number of families in a small geographical area with little access to activity further afield. Interestingly enough, when you spread the geographical area to encompass several rural communities an element of the heterogeneous seems to emerge. Activities in one community will differ sufficiently from those in another for the inhabitants of both to be aware of them. There is an old Glasgow saying that 'they're queer fowk who live in the Shaws'; in other words, the people on the other side of the mountain are always a shade peculiar – they really don't do things the way they *should* be done.

On the global scale it is easy to mistake the ubiquity of Coca-Cola for a growing process of homogeneity of intercontinental proportions. This is so of most modern cities. Battery-human architecture permeates the metropolis from Djakarta to Brussels. There are transistor radios in Kinshasa and TV sets in Ulan Bator. My own reponse to this is that they will probably have the same impact on heterogeneity as did the wheel: they will enhance it. Admittedly, the wheel has been trundling around somewhat longer but the impact of cheap mass-produced electronics on communication is likely to be just as (excuse the pun) revolutionary. This means that what we are liable to find is not the Global Village,[4] not an expanded version of a rural hamlet, but rather an extension of the city. Megalopolis is indeed likely to cover the world, at least figuratively, within the next fifty years.

There should therefore be an increase rather than a decrease in heterogeneity.

Where something new appears within the ambit of an individual's consciousness he or she can accept, reject or simply ignore it. For example, let us remember that five hundred million people around the world watched a country boy from Wapakoneta, Ohio, make one giant leap for the United States when he placed his boot on the Moon. Thereafter the television audiences dropped dramatically, picking up only slightly when Apollo 13 promised, and lived up to, the space fiction papped out by numerous TV stations around the world.

There was no homogenisation. The world did not overnight accept or reject or even ignore spaceflight. What tends to happen in the late twentieth century is that individuals having access to such a variety of communication sources produce a variety of personal opinions and responses which become in themselves new sources for others. Even where there is a quite distinct argument between two factions on any subject, there tends to be a wide and changing span of opinion on both sides.

There is a school of thought that would have me think that the very heterogeneity found increasingly around the world is but an indication of the much more subtle process of global homogeneity. Travellers and tourists complain that foreign parts are losing their regional flavour. This is partly true but not particularly important. There is still and has always been a great preponderance of local preference and tradition which novelty does not destroy. Preference and tradition are, however, not nearly so static as some people seem to believe. They change. Increased communication facilities will help them change more easily. Nevertheless, I feel that, despite the appearance of Chinese and Indian restaurants in the East End of my home town Glasgow, the Big Dirty City will never become a blend of Delhi and Hong Kong sublimated in a universal Manhattan-type gel.

Societies generally, as well as cities, seem to be becoming increasingly heterogeneous. There is a greater diversity of factors operating on the lives of individuals in most parts of the world than in previous times. Admittedly, poverty is still the dominant factor for the majority of the human race, but even among the poorest new influences are bearing in upon their lives, although in their case seldom for the better.

Globally we are aware that fashions in dress as well as politics can flit rapidly around the world. Even within the confines of our planet we are becoming increasingly heterogeneous. When we move into the realms of interstellar exchange we take another quantitative leap. If I am wrong and communication is by means of long-distance radio messages, we will never listen to the same star twice, to paraphrase Heraclitus. Human culture is liable to change in response to an ETI's signal and the ETI is itself going to change in response to our signals if it is interested in communication.

It would be foolhardy as I have mentioned earlier to regard other AMLs as having the same kind of social structure as ourselves or anything remotely similar (they may be an 'it', a solitary vast and complex organism as in *Solaris*). To extend this line of thought, I have to confess that I regard the idea of a pan-Galactic supercivilization as an overwhelmingly anthropomorphic one. To that mutually agreeing group of CETI thinkers who see the Galactic Club as some kind of super United Nations I must quote the words of Sam Goldwyn, 'Include me out!'

'There is no point in simply demolishing something unless you have an alternative to put in its place.' I agree. I attacked the current feeling that we should listen for interstellar radio signals, preferring an investigation of Earth and the Solar System for extraterrestrial

artefacts. Likewise I would like to put up an alternative type of Galactic Club to the supercivilisation so beloved of my fellow SF writers (Galactic Empire is one of the cherished images of many very good SF writers) and of some CETI specialists.

We may be alone in the Universe in that we are a unique AML. We may go exploring the planets and move out into the rich starfields far beyond and find nothing remotely similar to Man's mind for a long time, centuries or perhaps even millennia. We may be aware that there probably is a great deal of exchange taking place between lifeforms with which we simply cannot communicate.

There are two strategies open to us. The first is to go on searching until we come across an AML which can at least partially interact with our mentality. The second is to try kicking in the door. The latter would amount to an ultimatum which hopefully would force the ETIs to attempt contact with us instead of coolly ignoring our presence. Let's say we grow up technologically as nasty as we are today and decide to visit the home system of one particularly supercilious bunch of jumped-up bracmopods and slowly set their star on the road to going nova: 'Speak to us or we'll blow up your sun, so there!' I will not dwell on what the consequences of action like this is likely to be. I prefer to imagine that by that time we as a species will be considerably more mature than we are presently. If it looks as if we are not going to mature then we should take steps to bring this about. It would be irresponsible to let Man loose upon the cosmos, as some kind of superpotent technological vandal.

It may be necessary to manipulate our genetic material in order to produce a really sane species. Koestler and others have argued that there is something profoundly pathological in the very nature of Man.[5] We may have to change our nature and in doing so become something other than Man. Perhaps a new gland may be introduced to our physiology which releases an enzyme particularly designed to suppress those physio-psychological mechanisms which encourage us to indulge in such sports as avarice, egotism and war. The presence of other enzymes which cool the body temperature but stimulate all mechanisms so that they operate at normal body-temperature rate may be the answer here. The structures we wished to suppress would be provided with a barrier to these enzymes and would thus function at a low metabolic rate; in other words they would be sluggish compared to the rest of our activity. We are certain to tumble wildly down many well disguised pitfalls in exploring territory such as this but, to play with the grown-ups we will have to give up

behavioural short pants and tailor ourselves some decent adult clothes.

The strategy of finding someone who can listen among the ETIs is the only viable one for entry to the Club. Searching among the stars may produce a likely sponsor, one who can equate a certain 'angular' appreciation of the Universe with one of our own.

To return to the reverse zoo hypothesis, where the ETIs are there in open evidence before our eyes but inaccessible, let us imagine that there is a party going on inside a large house. We suspect that a lot of our friends are likely to be inside enjoying themselves and we resent being left outside in the cold lonely winter night. No amount of ringing the doorbell is going to help. Everyone is having too good a time to bother answering it.

The only solution is to pick the lock and walk in.

If there is no way of finding someone to talk to us in terms which we can understand then we must find a way of talking to them. Mohammed is reputed to have had a similar problem with a mountain. In a way this resembles the choice between listening for radio signals over the vastness of interstellar space and actively scouring the local interplanetary neighbourhood for renewable spaceprobes. Instead of hunting for something which may or may not be there, in this case an ETI which can think like us in some respects, we should develop a machine which is capable of producing non-humanistic views of the Universe based on data about the lifeforms concerned. (Here the word 'machine' is being used very loosely. I am assuming that when this event takes place, when we are preparing for membership of the Club, the line distinguishing between the human being and his creations will have smudged virtually out of existence.) Earlier in these pages I speculated about there being colleges of vN in most star systems which would have most likely evolved their own *lingua Galactica*, and this would certainly act as a starting pointer for us.

The problem which we shall face after encountering the vNs is the fact that although they will represent a 'frozen' common level of what we see as technology, the AMLs which created them will have continued to change. This is important because of the disparity between astronomical and human timescales. A few thousands or millions of years is, astronomically speaking, quite insignificant but to us is a span widening from the history of human culture to the very appearance of mankind on this world. If vNs have been arriving with some regularity over the past five billion or so years we have, as you can see, something of a daunting task on our hands. The Advanced Mental

Lifeforms may be just so advanced that they are totally beyond us.

If this is so for us then it was probably so for each AML on reaching the vN equivalent stage. In this event there may not be a Galactic Club for us. Perhaps all ETIs exist in complete temporal isolation from one another until such times as their 'cultural' histories begin to take on astronomical proportions and the age differences grow less meaningful. This would have an analogy in human terms of how important an age difference of, say, ten years is to two individuals. When one is twelve and the other two years old the difference is enormous. When the former is ninety-five and the latter eighty-five the difference has become almost insignificant.

In this sense, entry to the party is a parallel to being born. But the onus of childbirth, all the pain and struggle, belongs to ourselves. The rewards which lie in that new life are completely outwith our present grasp.

We must change to be 'born' in the same way that the fertilised egg changes to embryo, and the embryo to foetus, before birth can successfully take place. In our case the physical changes will be the least important except inasmuch as they allow increased enhancement of our minds' capabilities. With the blending of Man and machine physically and mentally the synergetic conference of brains functioning as superminds could become a reality.[6]

Bernal envisioned a society in which human brains were interlinked, supported and enhanced artificially. This is a possibility which should not be ignored. The problem with organic material is death. What may well happen is that the intricate and dynamic correlation of electro-biochemical elements which comprise the brain could be transcribed into crystal where the lattices and interstices might take the part of cells and synapses in our nervous system (see page 70).

At this point we would be able to have almost total control over our further evolution. We would be able to produce gigantic crystals containing millions of minds in chorus, all extended in their capabilities and enhanced within those capabilities by integration with artificial intelligence. At this stage there really will be no point in trying to differentiate between Man and his machines. At this stage we will have an alternative to death, because, apart from the possibility that the crystals will be nearly immortal, they will be capable of transferring memory and relationship structures. They will be capable of remembering how these can be regenerated, which would amount to a cloning of minds. There would also be the potential to produce deliberately a far greater mental diversity

among the new species than there is among our own. Diversity is the keystone of survival, so this 'solid-state society' would have considerable survival characteristics.

If the *lingua Galactica* of the vNs exists, it should in some instances be able to help us set up a new science of environmental behaviour studies, which we call ethology but which would in this context become xenethology. With luck some vNs will contain details of the developmental history of their makers. This will give us a lead, however tenuous, to the motivational structures within the AML which built this probe's ancestor in a remote part of the Galaxy in the very distant past. We should endeavour to observe a number of such cases, illustrations of AMLs going through processes akin to our own physical and behavioural evolution from a primitive single-celled bacterium to a complex mammal with involved social graces and disgraces. This could illustrate how the various angular differences between mental lifeforms may orient in regard to one another. We may have to come to terms with different developmental processes, some of which may not even be particularly closely allied to evolution in the terrestrial sense at all. Being an optimist, I assume that if other AMLs have overcome this conceptual problem then so shall we.

We will then travel into the realms of abstract behaviour, the xenethological equivalent of mathematics, moving into the realms of 'imaginary or complex numbers', because we will be dealing with the translation of non-human behaviour into terms which we humans can understand. There will be only certain aspects initially, and those the ones closest in relation to our own behaviour, which come across strongly. We will then be able to redesign and create new minds which can cope more readily with the human and non-human. We will be creating differentials.

When we are really adept at assembling the differential intelligences we will have altered the conceptual tennis racket with which we swat the Universe's tennis balls. The mesh size will be that little bit finer; the racket face will be beginning to curve and grow wider. The change will be significant. When it becomes sufficiently significant for us to set up meaningful interactions between ourselves and one of the Club we will have arrived on the other side of the threshold, stepped inside the door, moved into the new world.

Diverse flexible AMLs may thus set up mental differentials between themselves and other AMLs. It will be the equivalent of communicating with one entity with whom we have nothing in

common *via* another who has something in common with us both. These others with whom we can communicate to some extent, the Human Analogues, will dominate our relationship with all members of the Club. Those areas within which we have achieved a common angular perspective will become increasingly important not merely to ourselves but also to them.

Now we come to the point which is perhaps the most hubristic of all. We will be prized and valued members of the Galactic Club. If, as I suspect, all forms of Advanced Mental Life are mutually exotic, then each will be prized by the others as a new and enlightening approach to the problems of existence within a Universe which can be understood from so many different and seemingly inconsistent viewpoints. We will not only require differential AMLs for communication but we will act as differentials ourselves for others, enriching the ever-changing dynamic of the Galactic Club.

From this point on there will continue to be great diversity and continued change resulting from it, but terrestrial evolution will have been superseded. We will no longer change through the fissioning process of random mutation and genetic drift alone: instead there will be a process of synthesis based on the mutations.

The new will be formed by creating deliberate as well as random variants and combining these to form still other variants. Thus, when we enter the Club, we will become a member in the most intimate sense. We will combine with many of the Human Analogues to create wholly original mental lifeforms.

As I have said, the Galactic Club will be nothing like an interstellar United Nations. What then might it be like?

I imagine it as something like Babel; an enormous conference of linguists each with a different behavioural language and each attempting to communicate with the other, the principal problem being that when they do make a breakthrough it changes their own language and the language which they have 'penetrated'. Some languages are impenetrable to certain others, and these need professional translators skilled in the languages which are mutually exclusive. For meaningful communication between all members, chain translations have to continue. The problem is that every message received changes the receiving language, and consequently its response is a novel variant which creates more change.

Special translators will have been bred specially to meet the needs of the conference. They are immensely flexible and capable of handling rapidly shifting diversities. They are the result of exceptionally close intercourse between conference members. The special

translators are always at a premium because new members are always strolling into the Club with naïve misconceptions about everyone inside speaking their native tongue. These kids have to be handled delicately because their own language can describe aspects of existence which none other can. So we may expect a special translator as the Club's doorman, a staff member. I hesitate to speculate on the Club's executive committee.

An ever-changing population of vNs in the Galaxy might be both door and doorbell, elements with which we forcibly interact in order to let the doorman know that we are outside.

To appreciate how the Club might function at levels above that of basic membership, the Club analogy is best dropped. My own interpretation is that it might be better to employ the living body as a metaphor. The variety of differing AMLs might be regarded as the numerous teeming microscopic constituents of the single cell. Then there are the specialisations of cells into various types of tissues. The tissues are employed by different systems working in close coordination to support the organism as an integrated dynamic whole. Here the vNs would be regarded as the basic material of the epidermis, the outer part of which is virtually dead. The live tissue lies just beyond.

For what it is worth, that is my personal vision of the Galaxy and Man's future within it. We are unique and as such highly desirable as a constituent of the vast heterogeneous system out there.

Perhaps, if we never achieve anything more than planetary devastation, we shall not be missed. The vanished potential will never have been appreciated. Let us then look to the stars as we have for millennium upon millennium and realise that the only route which can take us there lies buried in the dark of the human heart, that there is no way to reach it other than that of compassion and the will to change.

Epilogue

What Do You Say Before You Say Hello?

The President's scientific advisors were really worried. The Press Secretary could see that. Generally they wore the standard patina of intellectual profundity with the care other career professionals lavished on the selection of neckties and office furnishings.

Today they sat, slouched, massaging tired faces with their soft hands. Nobody was name-dropping, 'seminal paper'-dropping or even conference-dropping. There was a lot of trouble somewhere and nobody was telling the Press Secretary a damned thing about it.

He scowled.

The President had told him to leave everything and come up to the Oval Room. This meant that within the next hour or two he was going to be under a barrage of demands from every paper between the *Herald-Tribune* and the *Bengal Engineers' Daily Digest*.

Everybody always found out before the damned Press Secretary!

The door opened and heads turned. The Man's personal aide, a balding youngster in his mid-twenties, twitched a smile at them from his thin face and indicated with a brisk semaphore of his right forefinger that they were to go inside.

'I don't want everyone to start speaking at once,' said the small cracked voice from the big svelt Philadelphian. 'Jess, you are the one who is really important in this room. You and only you ask the questions.'

The Press Secretary felt ice crystallise along the convolutions of his larger intestine. If he was the kingpin at this meeting the world was standing on its skull.

The lights dimmed a little and a television plate hanging from the wall splashed a shudder of colour through the room and then congealed into a picture.

There was a shallow grey dish-shape suspended there, and beside it, casting a shadow, was a large flat disc. Behind them, below them, was the unmistakable crusted acne of lunar Farside. Jess knew what this was. The NASA/ESA publicity machinery had been crowing about their miraculous radio telescope since it was completed three years back at the turn of the century. It hung in a continually computer corrected orbital alignment which held it forever some 60,000 kilometres above the other side of the Moon. Here it was completely shadowed from Earth's radio noise and annoying

discharges from the planet's radiation belts. The great disc performed the same shielding job with regard to the Sun. The instrument was, apparently, capable of identifying radio binaries in the Andromeda Galaxy. He knew that was supposed to be impressive!

A clipped voice issued a hurried accompaniment.

'Two months ago the ten-thousand-metre dish above Farside picked up an unusual source during a standard calibration run. The source was issuing a complex repeated signal interrupted by what appeared to be other non-repeated signals containing elements related mathematically to one another and to the repeats.'

The picture became a bright blue pulse tracing against a black grid. There was a series of numbers ever rising in value at the top right beside a designation which read ETI PROBABILITY PROFILE.

Jess understood now.

'Deep space planetary monitors around Jupiter and Uranus obtained and confirmed infrared fixes placing the source at some five and a half thousand billion kilometers from us. Parallax coordinates substantiated Doppler information to the effect that this source is moving rapidly on a course taking it into the Solar System and the vicinity of the inner planets. On discovery it was travelling at 12% lightspeed. Its deceleration, if maintained, will place it in an elliptical orbit between Mercury and Venus less than ten months from today. Any doubts that this object was other than an extraterrestrial artefact were dispelled at 0113 hours Eastern Standard Time today when a reply came to the CETI experimental package automatically authorised, designed and transmitted by the ten-thousand-metre's twin IBM Fifty-Fiftys three weeks ago.'

A few whispered oaths assailed the ears of the unbelieving Jess. A message to aliens authorised, designed and transmitted by a batch of computers! What goes on?

The picture snapped to a grainy representation in monochrome. It was so long since Jess had looked at black-and-white TV that he had to do a double take. He saw a slowly turning ring with a metallic tube at its central axis. A firestream issued from the tube. Some kind of rocket, Jess surmised.

'It is now fairly clear that this is a world ship. The ring in the picture is hollow and contains a diverse rich biosphere representative of the ETIs' home world. Their power unit is under analysis and seems to be basically some form of mass annihilation process with which we are not presently familiar.'

The screen was still showing scenes and talking when the Press Secretary stood up and for the first time in his life bawled at his boss.

'You allowed this bunch of shmucks to incorporate CETI programs into those Fifty-Fifties. You became so blasé about our contacting life from elsewhere that you let them philosophise happily away while the computers did the real work! Well, now we know. Now the whole bloody world knows!

'What do we do about it, Mr President?'

In the adjoining room a 'phone began to bleat.

This is the kind of science fiction which might become horrifying fact. So many repetitive tasks are digested by attitudes of complacency that it is often difficult to ensure that a great deal of control over them stays directly in human hands. It is often not merely tempting but necessary to delegate much of the work to computers. Where the task is interesting in some element it might be continued, but with results appearing no nearer more and more of the work is likely to be unloaded on the machines, especially as they themselves grow increasingly smarter. (To my knowledge there are no plans by IBM to produce Fifty-Fifty series computers, and so far it looks unlikely that we will see the ten-thousand-metre radio 'scope within the next thirty years.)

The ETIs of science fiction are often beings which, if not at our own level of technology, are a mere thousand or so years ahead. Personally I don't see this as possible, although even a gap of a few hundred years would be staggering. In the scenario above the aliens are perhaps one and a half centuries ahead. However, it may be feasible, with a stretch of the imagination.

There is a current theory that planetary systems are formed among groups of stars by a supernova[1] occurring within or near to that group. This would entail that many of the planets of nearby stars would be approximately as old as those of our own Solar System. Again I am not too happy with this. There is the old comparison with the age of the Earth and the eight thousand or so years men have had civilisations recognisable as such. Take the age of the Earth as equivalent to one day and civilisations have been around for less than the last one-fifth of a second. Even if the other planets of other systems are producing AMLs but a minute or two ahead ...

This may not be as depressing as some people may see it. Regard the planetary systems produced by a supernova as a kind of family. This means that our parental exploding star could have ensured that our local area of the Galaxy has been and may still be under intense scrutiny from expanding spheres of vNs.

There is, of course, the possibility that we are the first in this part

of the Galaxy, perhaps even the first AML in the entire history of the Universe. These are again *ad hoc* hypotheses and disprovable only by extensive ETIs.

Evidently the science policy makers in the SF scenario above were rapidly coming to the conclusion that we were alone by deciding to leave decision-making on the subject to the computers. They may not have made this choice consciously, but this is what it amounts to.

The last words I put down for Jess, the Press Secretary, are the whole point of the little tale. No one so far has thought about what we do once we discover ETI. It seems folly to me that governments throughout the world are considering investing millions into CETI without making more than the most basic steps to consider what the consequences of an encounter are likely to be.[2] All that we ever hear are individual opinions. Many entreat us to leave alone the whole possibility of contact with other intelligences but the alternative voices seem more concerted in their efforts and the public seems increasingly interested in what they have to say. Having a preponderance of literate popular figures in the CETI camp does help, of course.

It is crucial that we review and continue to review what the prospects of CETI are likely to mean to the human race. The odd chapter in a book, a couple of ill-attended hours at a CETI conference, and a dusty report or two over a decade old are just not good enough.

There are, basically, two types of encounter, so it should be fairly straightforward examining these and our response to them: the types are full encounter and transient encounter. Of these two there are two simple variants: active and passive. Let me provide some examples:

1A puts us in permanent close contact with ETI. Establishing communications with inhabitants of UFOs would fall into this category but I believe that opening a discourse with the local vN 'college' will be the most likely achievement in this category.

1B would be the discovery either of remains of ETI visitation to the Solar System or of a databank left for us by them in some bygone era. Inactive spaceprobes would fall into this category.

2A should be something like our setting up a temporary discourse with an intelligent starprobe which was passing through our own system without decelerating. They could actually be doing this frequently right now and we would be unaware of it.

2B might be a short burst of ETI radio signals which we picked up fleetingly before they disappeared, but were unable to decipher.

Radio CETI – that is, actual communication exchanges – would fall into category 1A whereas SETI, search only, would place any signals in 1B should we decide not to respond.

What about our own spacecraft encountering beings when they arrive at distant systems? Again using the cosmic-clock analogy we are liable to be a second or so ahead of our present stage when this occurs. One hopes that we will be deeply involved with the variety of vN we have discovered and will not try playing God with AMLs which have not achieved capabilities comparable with our own. May interstellar distances please act as quarantine to keep them safe from us until our minds are suitably overhauled.

The problems which might arise on our encountering another AML which was virtually matched with us in development are hair-curling. Behavioural anomalies on either side are likely to be viewed with disfavour by the unenlightened eyes of the other party. Given a high level of technology and a low level of responsibility someone is likely to make a step which we would all regret. Luckily it seems virtually impossible that we are going to encounter anything near our own level apart from vNs if even they are there.

Nevertheless, the outside possibility that we become involved in an encounter, even with a vN, which is potentially dangerous is reason enough for us to start thinking about xenethological theory right now. Admittedly, it is an area of pure speculation: nobody can guess with the remotest pretensions at accuracy what behaviour is likely to result from extraterrestrial environments.

There is one attitude which we must dispel from the start. It is one which had been beloved of SF movie moguls and writers since the days of H. G. Wells and can be suitably illustrated in this quote from *War of the Worlds*:

> Yet across the gulf of space, minds that are to our minds as ours are to those of the beasts that perish, intellects vast and cool and unsympathetic, regarded this earth with envious eyes and slowly and surely drew their plans against us.

Certainly the most obvious and most frightening consequence of encounter is that the human race may be annihilated. This is rather a peculiar way of looking at the whole subject. It reminds me of the peculiar attitude of some patients in mental institutions that everyone in the world is plotting for their destruction or that the safest place to stay is in bed. Going out of doors might lead to all sorts of disasters from being struck (either by lightning or a motor vehicle), to being robbed, raped, murdered or catching a disease from some dirty person you might pass in the street.

There is a more refined version of this which is that we will suffer an insuperable ego blow should beings vastly superior to ourselves make themselves known to us. The great danger here is that we will have nothing left to discover, all the vistas will have already been explored and there will be nothing left for Man to do but vegetate miserably. Apparently the same fate would then befall all of us as that which overtook the Eskimo when North American big business and Westernisation in general destroyed the traditional way of life.

The idea of ego blow is really the largest segment of unmitigated excrement I have come across in my years of reading in the field of CETI. There are many points at which to begin and rave on about just how fatuous it is, but let me start thirty thousand years ago. The way of life of the hunter-gatherer peoples existing at the end of the last ice age has all but gone. It is in the nature of life on Earth and in the nature of human nature that the more successful tends to replace the less successful where they are in competition. The Eskimo way of life may well pass, regrettably, within the next few decades; this does not mean that those descendants of the Eskimo peoples cannot adapt successfully to other ways of life, and there is a considerable diversity of lifestyles available to individuals in the developed countries of the world today.

The second point, and the really salient one, is that our world today is a thriving mixture of peoples with varying types and different levels of economic, social and technological enlightenment. The historical examples of Japan and China in their response to a cultural and technological challenge over the last century show ego blow as the inane concept which it basically is.

Finally, those individuals who believe that there may come a point when any AML really can know everything there is to know have a very different concept of the Universe from that held by most philosophers and scientists today. If we do encounter a non-omniscient ETI then we will be in a position of having vast realms of knowledge and perhaps technological application to bring to bear upon them, the uniquely human viewpoint. When we meet a superior ETI we are unlikely simply to throw up our hands in despair, sit down and die. Certainly there are human beings who do this. If they were in the majority the species would be finished within the next few centuries whether or not we bumped into the little green men.

Historical example, as I have shown earlier in these pages, indicates that isolation as policy does not tend to work. In Japan and China the forces which ended isolation were as much internal

as they were foreign. Even if the reverse zoo hypothesis proves to be the case at some point in the immense spread of the future, some humans, whatever their mental and physical form, are going to attempt to join the Club.

The 'leave them alone' school, the 'Zealots' as Toynbee would call them, will also raise the hue and the ringing cry when we discover vNs in the Solar System, as I feel sure we may do well within the next century. They will point out that we should not investigate such objects (leave them alone and they might go away or perhaps simply ignore us). Even if we just want to poke around with an old inactive probe they will come up with objections. In this case it is fairly obvious what the whine is likely to be: the technology which will be acquired from the probe is the product of a more mature culture and we are not yet ready for it.

If the probe is the product of a technological lifeform whose capabilities are some century to a century and a half ahead of us, then (if we discover the probe around the year 2000) it will bear the same relation to us as would an abandoned broken-down radio telescope to an astronomer of the mid-nineteenth century.

There are three problems which face anyone confronted with a mysterious piece of equipment. They will not be at all easy to overcome. The questions any aspect of a probe would raise are: what does it do?; how does it do it?; how is it made?. The first two are the comparatively easy questions. They are causally related. The final question is the one which really will push forward the minds of scientists and engineers confronted with it. The analogy might be in the plans for an aircraft like the supersonic airliner *Concorde*. Anyone reading the technical press, and even some of the popular press, during the years of its design and development, would have come across reams of research papers, design diagrams and amazingly detailed plans. When a little piece of industrial espionage was indulged in by a nation which wanted to build its own SST what was stolen was what was unavailable – the details of how you *make* the functional product.[3]

Basically the point which I am making remains the same. It is going to be a day of some excitement whenever the encounter takes place. Even if it is just an inert junkpile drifting around the Sun the stimulus which it will deliver will be phenomenal.

The impact of the space race on the world's economy appeared from my uneducated viewpoint to be very positive, very strong and disseminating advantages to almost every country on this little planet. There seemed to be a big dumb booster sitting under the financial mausoleum of the 'fifties. Sputnik activated it. The

economy of a country, never mind the world, is like the weather: there are a lot of experts but the damn' thing does what it wants to anyway.

If a handful of plastic and thin metal did that in 1957 the lift value of ETI encounter might raise the standard of living for the majority of the human race slightly above the poverty line. Hopefully that would just be for starters. This kind of potential financial thrust is surely reason enough for governments and industry to investigate the possibility of CETI as a worthwhile area for substantial investment.

It is interesting to note that there is an increasing tendency amongst businesses to look into the future. There are numerous industrial enterprises which invest heavily in market assessment and trend prediction. They frequently rely on the expertise of professional economists to build models of the future and see how invested capital is liable to grow under various conditions of political, technological and even meteorological change. Competing industries are matched as are competing corporations within the industries concerned.

All this is very healthy. NASA has recently brought before its critics a report indicating just what kind of contribution it is capable of making to the US economy alone.[4] The figures, although heavily criticised by the anti-space lobby, are substantial. The message should have been clear for some time now: space programmes pay off.

A CETI programme should also pay off.

Studies in this area should be initiated as soon as it is feasible to do so. Like now. The president in the little fictional introduction to this final chapter had no background knowledge with which to handle the encounter situation. This ignorance is quite unnecessary.

Apart from the possibilities of projecting how a CETI programme might influence the economy, let us also project what a successful encounter could do to it. Let us see what that encounter could do to us in other areas by running computer games similar to the complex sociological studies in which large-scale multifactor situations are modelled and allowed to change according to the patterns in which these models appear to change in real life. This way we will gain some valuable advance indicators of how the world will react to encounter.

There is, of course, the presentation of encounter to be considered. How do you tell the public and who tells whom what in the first place? Gaming encounter situations can only be helpful.

The personal and personality dynamics concerned in a situation like this are important. How is the US public going to take the news from a president at an all time low in his popularity? In this case it may perhaps be advantageous to have a publicly highly rated well known newscaster to break the news on all the networks simultaneously. The number of strategies for tackling this event are quite diverse, and the more often they are gamed the greater will grow the body of proxy experience which should give some pointers as to which are likely to work fairly effectively, and the ones which will possibly be disastrous.

Furthermore, as we are moving now into an era when CETI is respectable, it is time that we started coming to terms with how we go about altering our ways of looking at things. Perhaps this is how we may make first steps in coming to terms with the ETI, when it becomes a reality. Again, we would be involved with a gaming principle. Some fairly sophisticated programs, with a lot of lateral thinking in their operation, would be required. In effect, what would be assembled in the computers would be mock AMLs distinct from our own. A telepathic/telekinetic ETI might be modelled, one with a very poor ability to think mathematically. How do we interact with this?

The trick is not to delude ourselves into believing that we are devising approaches that will provide an easy route to understanding AMLs other than ourselves. The value of this exercise is that we will be seriously approaching the problem as one which has non-human aspects. We will realise that these aspects are likely to be fundamental. The plus will come from having exercised ourselves. We will know more intimately than ever before what the limitations are to Man. Perhaps then we will be willing to change them.

Will such gaming have an advantage when run on an international basis? There is the chance that this is the one area in which the Warsaw Pact and NATO could contemplate a joint defence operation – planetary defence. This may help international relations by warming them from the chilly standoff climes which can precede the corpse-cold storms of active warfare.

This may not be a particularly bad thing. More emphasis would be placed upon cooperation in space and less upon confrontation on the ground. It would, of course, be inadvisable to let the military take over CETI. They may hit the first pinpointed vN with a missile or a high-energy pulse and vaporise it, out of sheer hysterical fervour.

Put the onus of the search upon international teams of civilians

and let there be a permanent UN committee to oversee the project, make decisions and allot funds.

So much for the ideal. It may come about but what I envisage as more likely is a long heartbreaking radio CETI search which winds up eventually having no convincing results to its credit. When contact is finally made with vNs we will botch it. The cumulative effects of TV and comic book space invasions will bear fruit.

In the world of SF it would be so very heartening to find some philanthropic soul putting up an annual prize for the most responsible encounter situation in a comic book, TV show, movie or short story in any language. Some kind of move to rid ourselves of Wells' and Welles' Martians, once and for all, has to be made as a matter of public education. Likewise it would be encouraging to find a more enlightened attitude amongst the English-language press. The aura of crankishness must be dispelled.

An aid to dispelling this could be the founding of an institution which would meticulously inspect all supposed 'evidence' for UFOs and ancient ETI encounters. Such a body would hopefully not merely be a bunch of armchair bound disbelievers but would actually initiate search programmes for archaeological indicators and devise schemes for testing various UFO theories. The laudable North Americans who have formed the impressive Committee for the Scientific Investigation of Claims of the Paranormal might set an example here. Perhaps with some more generous funding they may even be persuaded to set up a similar open-minded body of impressive sceptics willing to look for ways of disproving their own hypotheses.

We must educate and be educated. We must dispel the arrogance and despair which are the products of believing both that we are alone in the Universe and that the Universe is planet Earth alone. Out there are living minds the likes of which are as beyond our limited imaginings as we are beyond theirs.

If we realise that we, like they, are a unique voice whispering in the dark a story which will never be heard again, then perhaps we will begin to see ourselves as precious, as all lifeforms surely are. Then perhaps we will begin to treat one another with the respect and compassion we so surely deserve.

Then perhaps we will begin ...

Appendix 1

A Checklist of ETs in the Cinema

This is a selective compilation of films in which ET life is a primary ingredient. Those asterisked (*) are the ones which in my opinion have something to say about encounter situations. Comment is mostly excluded but there are some notes listed at the end.

Message From Mars, 1913.
A Trip to Mars, 1917.
First Men in the Moon, 1919 & 1964.*
Aelita, 1924.
Flash Gordon, 1936.
Flash Gordon's Trip to Mars, 1938.
Flash Gordon Conquers the Universe, 1940.
The Purple Monster Strikes, 1945.
Superman, 1948.
Rocketship XM, 1950.
Flying Disc Man from Mars, 1950.
The Thing (From Another World), 1951.
The Day the Earth Stood Still, 1951.*
Cat-Women of the Moon, 1951.
Man From Planet X, 1951.
Flight to Mars, 1951.
Radar Men from the Moon, 1951.
Red Planet Mars, 1952.*
It Came from Outer Space, 1953.*
War of the Worlds, 1953.
Invaders from Mars, 1953.
The Lost Planet, 1953.
Target Earth, 1954.
Devil Girl from Mars, 1954.
Forbidden Planet, 1955.*[a]
Beast with a Million Eyes, 1955.
This Island Earth, 1955.
The Quatermass Experiment, 1955.*[c]
Invasion of the Body Snatchers, 1956.[b]
Fire Maidens from Outer Space, 1956.
Twenty Million Miles to Earth, 1957.
Supersonic Saucer, 1957.
Atomic Rulers of the World, 1957.
Earth Versus the Flying Saucers, 1957.
Not of this Earth, 1957.
Kronos, 1957.
27th Day, 1957.*
The Giant Claw, 1957.
Invasion of the Saucer Men, 1957.
Quatermass II, 1957.
The Brain from Planet Arous, 1957
Attack of the Fifty Foot Woman, 1958.
Astounding She-Monster, 1958.
War of the Satellites, 1958.
The Space Children, 1958.
The Blob, 1958.[c]
I Married a Monster from Outer Space, 1958.[b]
The Brain Eaters, 1958.
Night of the Blood Beast, 1958.
The Flame Barrier, 1958
Space Master X-7, 1958.
Strange World of Planet X, 1958
The Trollenberg Terror, 1958.
It! The Terror from Beyond Space, 1958.
The Mysterians, 1958.
The Cosmic Man, 1959.*
Invisible Invaders, 1959.
Plan 9 from Outer Space, 1959.
Teenagers from Outer Space, 1959.
Missile to the Moon, 1959.
The Angry Red Planet, 1959.
Battle in Outer Space, 1959.
12 to the Moon, 1960.
The Phantom Planet, 1960.
Journey to the 7th Planet, 1960.
Visit to a Small Planet, 1960.
Village of the Damned, 1960.*
Man in Outer Space, 1961.
Children of the Damned, 1963.*
Battle of the Worlds, 1963.
The Day Mars Invaded Earth, 1963.
The Day of the Triffids, 1963.
Unearthly Stranger, 1963.
Invasion of the Animal People, 1963.
Invasion of the Star Creatures, 1964.
Robinson Crusoe on Mars, 1964.
The Human Duplicators, 1965.
Frankenstein Meets the Space Monster, 1965.
The Earth Dies Screaming, 1965.
The Night Caller, 1965.
Mutiny in Outer Space, 1965.
Dr Who and the Daleks, 1965.
Queen of Blood, 1966.
Daleks – Invasion Earth, 2150, 1965.
Invasion, 1966.
Arnas Infernales, 1966.
Destination Inner Space, 1966.
Mars Needs Women, 1966.
The Bubble, 1966.
Quatermass and the Pit, 1967.*[a]
They Came from Beyond Space, 1967.
The Terrornauts, 1967.
The Night of the Big Heat, 1967.
Destroy All Planets, 1968.
2001: A Space Odyssey, 1968.*[a]
Barbarella, 1968.
The Body Stealers, 1969.
The Illustrated Man, 1969.
The Astro-Zombies, 1969.
The Green Slime, 1969.
Night Slaves, 1970.
Slaughterhouse Five, 1970.
The Andromeda Strain, 1971.[c]
Yog-Monster from Space, 1971.
Solaris, 1972.*
Beware the Blob, 1972.
The People, 1972.
Phase IV, 1973.[b]
Dark Star, 1975.
UFO Incident, 1975.
The Man Who Fell to Earth, 1976.
Star Wars, 1977.
Close Encounters of the Third Kind, 1977.*
Starship Invasions, 1978.
Laserblast, 1978.

[a] Few SF films are imaginative enough to consider the fact that civilisations in the Galaxy may exist so far apart in time that they seldom connect on a 'live' basis. These ones do. They are all excellent encounter scenarios.
[b] These films come close to being asterisked. In each case I feel that the situation could have been more deeply explored, although admittedly this could have detracted from the storylines and the cinematic impact.
[c] The idea of a simple non-intelligent organism from space causing havoc is one which the cinema has left almost entirely unexplored. Two of the three films which have tackled it, *The Quatermass Experiment* and *The Andromeda Strain* are to be commended.

Appendix 2

Relativistic Black Holes

One of the great tricks of SF is 'hyperdrive' or 'spacewarp' or whatever. The purpose of this mechanism is to bypass the restrictions of Einsteinian Relativity theory; sadly, this puts a rather heartless limit on the speed at which science-fiction writers can propel our imaginary starships through the Universe. 300,000 kilometres per second, the speed of light in a vacuum, is the ultimate in velocities, apparently.

'Hyperdrive' negotiates a way around this by placing the starship or some elements of it outwith Einsteinian spacetime. The possibility that something akin to it may exist has been raised by Professor John Wheeler of Princeton. His 'Superspace' does not contradict Einstein at all and is in fact firmly based on standard Relativity theory.

How do we find a way of utilising Superspace?

This was one of the questions I pondered on when considering the possibility that ETIs may have discovered the appropriate mechanism, as we too may in the coming centuries. Could black holes be the answer? It has been postulated that they may be shortcuts through our own Universe or alleyways into another.

There are two ways of placing your spaceship in a black hole environment. The most straightforward is to bring them both together, the spaceship and the black hole. The other way is to turn your spaceship into a black hole.

The latter sounds just as difficult as merely finding Superspace in the first place, but this is not quite the case: in fact, it is a fairly simple process, in terms of Relativity theory at any rate. The clue lies in the fact that as a body travels faster it appears to become more massive. It also becomes shorter. The combination of these two factors means that, as a spaceship accelerates, it appears to become an increasingly dense object.

Black holes are objects which are so dense that, in crude terms, their gravity has crushed them out of contact with our Universe. So could our ship ever become a black hole in the eyes of the Einsteinian Universe? It would seem so. To travel at the speed of light the ship would have to acquire infinite mass and therefore infinite density. This is out. Long before the ship reached infinite density it would achieve the density required for it to become a Relativistic Black Hole.

Now anyone with a fairly basic grasp of relativity can see what, at first glance, appears to be wrong with this. The spaceship cannot become a black hole because the mass concerned is not the mass as measured by the passengers and crew of the ship but the relativistic mass as measured by an observer on Earth. In other words, the mass increase can only be measured by someone who is *not* aboard because to those who *are* aboard the mass is always constant.

There is, however, more to it than this. The spaceship does not and cannot become a conventional black hole but can its relativistic mass, measured by an Earth-bound observer, increase to such an extent that, to the same observer, the relativistic increase would generate an event-horizon? An event-horizon is the distance from the centre or 'singularity' of a black hole at which the escape velocity equals the speed of light.

Can relativistic mass do this? Does relativistic mass not merely represent increased space-time curvature but create increased space-time curvature measurable by an Earth-bound observer? If so our spaceship will eventually be engulfed by its own event-horizon as far as the observer is concerned, although not as far as the crew are concerned.

It will not crush itself into a singularity because from the observer's point of view the moment the hull matches the event-horizon all clocks on it will stop as will all movement. This will prevent it accelerating or decelerating.

Would it then have passed out of our Universe or found a short cut through it, or what?

The equation for the relationship between the diameter of a body and the mass it must have to take on the aspects of a black hole are known theoretically. This is:

$$D = \frac{4MG}{c^2}. \qquad (1)$$

where D is the diameter, M is the mass, G is the gravitational constant and c is the speed of light. So what we are interested in is the point at which the relativistic mass of the spaceship is equal to the mass factor in the above equation. As we already have a figure for the diameter (D) of the spacecraft we can change the above as follows:

$$M = \frac{Dc^2}{4G}. \qquad (2)$$

To relate this to the relativistic mass of the spaceship we should introduce the association between the ship's mass when it is stationary and its increased mass when travelling at relativistic speeds. As we are looking for the relativistic mass which gives black-hole density in relation to the diameter we will call the relativistic mass M, its stationary mass m and its velocity v.

The equation is found in the Special Theory and is

$$M = \frac{m}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}}. \qquad (3)$$

So, combining (2) with (3) we wind up with

$$\frac{Dc^2}{4G} = \frac{m}{\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}}};$$

$$\therefore \quad Dc^2\left(1 - \frac{v^2}{c^2}\right)^{\frac{1}{2}} = 4Gm;$$

$$\therefore \quad 1 - \frac{v^2}{c^2} = \left(\frac{4Gm}{Dc^2}\right)^2;$$

$$\therefore \quad \frac{v^2}{c^2} = 1 - \left(\frac{4Gm}{Dc^2}\right)^2;$$

$$\frac{v}{c} = \left[1 - \left(\frac{4Gm}{Dc^2}\right)^2\right]^{\frac{1}{2}};$$

$$v = c\left[1 - \left(\frac{4Gm}{Dc^2}\right)^2\right]^{\frac{1}{2}}.$$

..

We have an expression giving us the velocity at which a spaceship, or anything else, becomes a black hole. Or do we?

The problem with all those pretty equations is that they are based on non-Einsteinian maths. The fact that equation (1) falls into the

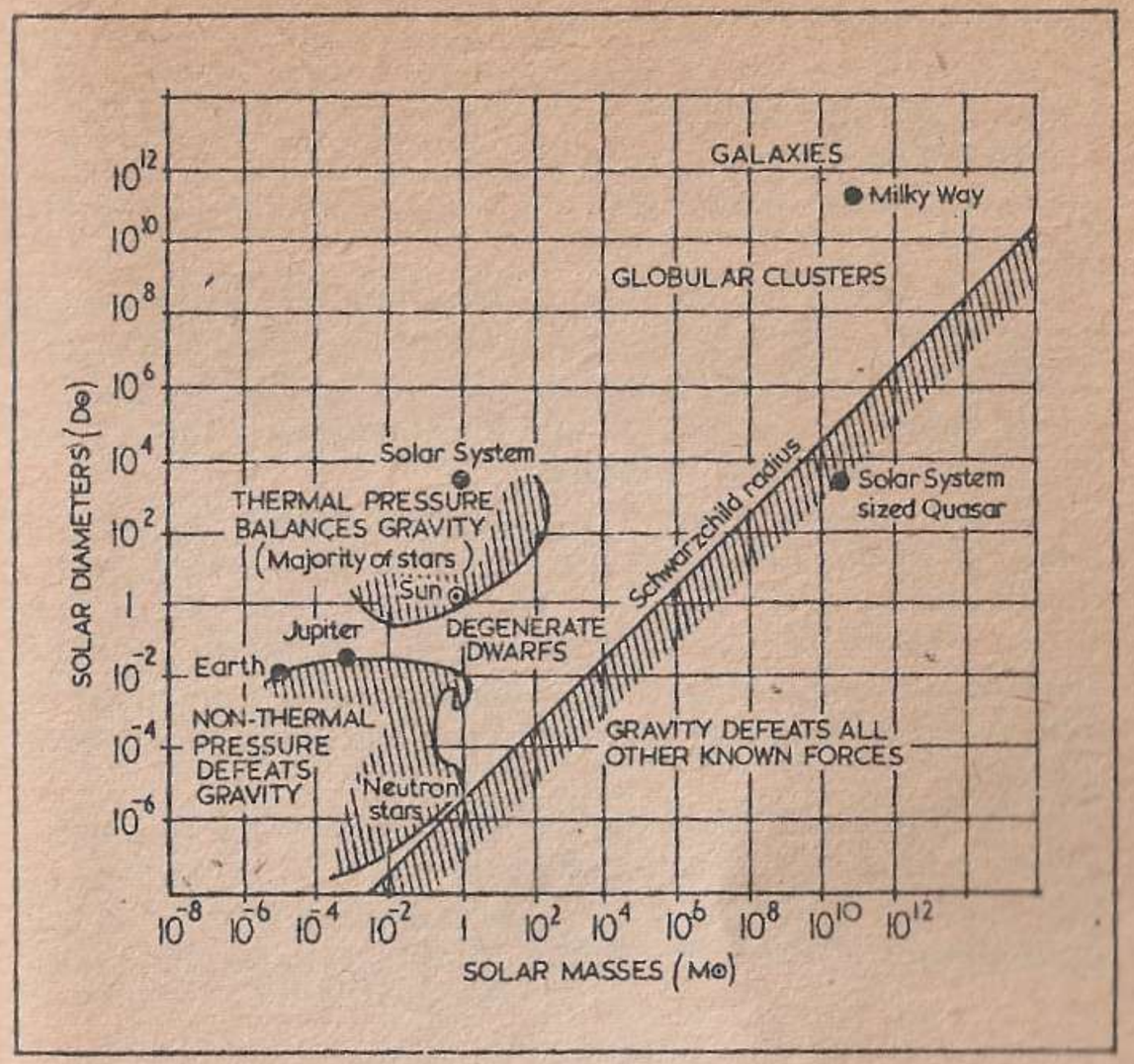


Fig. 1: The observable Universe in terms of solar masses and diameters.

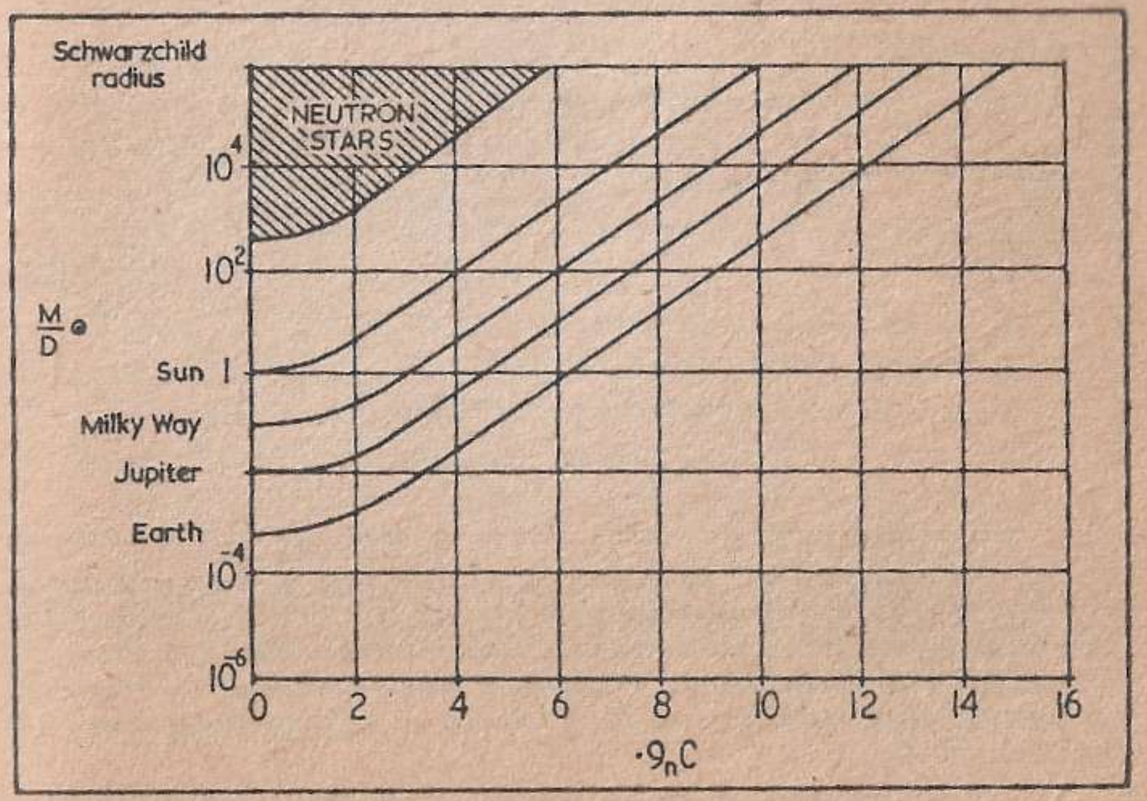


Fig. 2: Velocity and the Schwarzschild radius for a moving body.

category of high school maths happens to be a sheer coincidence as far as anyone can tell. This said, let us try testing the observable Universe and see if we can come up with any answers or indicators.

First of all, we can assemble a picture of the relationships between known objects' sizes and masses and the black-hole threshold.

In fig. 1 we can see that there is something very weird with the picture of the Universe that we might expect from our knowledge of black holes. Everything on the right-hand side of the Schwarzschild radius should be a black hole and thus invisible as light should, theoretically, be unable to escape it.

Quasars, however, appear to be sufficiently compact in size while somehow avoiding becoming black holes. Is there any way we can resolve this apparent paradox? What do we know about these distant objects of the Universe which relates to the RBH hypothesis? We know that they are massive and they are retreating from us at great velocities. Both of these make them candidates for scrutiny.

In fig. 2 the vertical axis on the left-hand side is a measure of objects' masses and diameters while the $.9_n c$ running horizontally represents the number of 9s after the point as a fraction of light speed (thus $.9_4 c$ represents $.9999c$). The shaded area for neutron

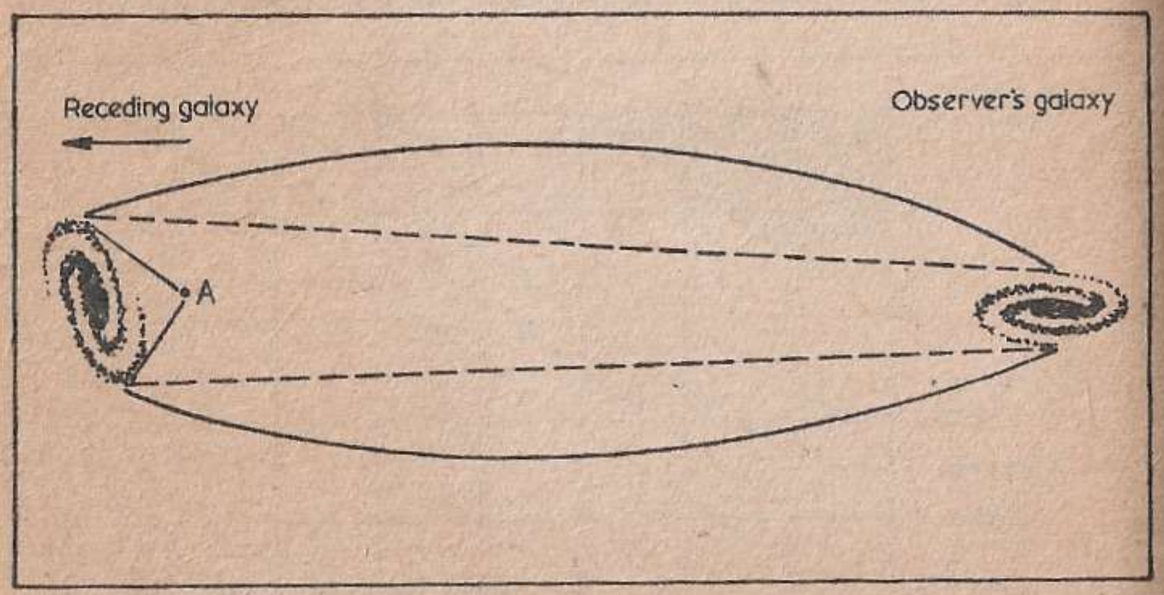


Fig. 3: Unbroken lines indicate actual path of light. This is curved between the rapidly separating galaxies but virtually straight for an observer at A who is so close to the observed galaxy that there is no cosmological recession. The broken line indicates the lightpath adopted in the absence of spacetime curvature induced by relativistic gravitational effects. Spacetime curvature induced by the Universe as a whole is ignored in this diagram.

stars in the top left includes stable neutron stars and those ones which are so massive that they are undergoing an irreversible collapse into the condition of becoming black holes.

Evidently, as soon as we start increasing mass relativistically among very distant galaxies we start to increase the number of black holes which they contain from our point of view. This should become evident at cosmological distances which imply recession speeds best expressed as fractions of light speed. The greater the fraction the more evident will become the presence of the relativistic gravitational effects. It should be readily observable in the bending it induces in the light coming from the distant galaxy concerned, as illustrated in fig. 3.

Relativistic gravity induced by relativistic mass is bending the light which a distant galaxy is beaming at us. This means that the light will be reddened as it has to travel further – gravity has stretched it.

To determine the redshift, z, of a body travelling at relativistic speeds you must combine the relativistic doppler effect from Special Relativity with gravitational redshift from General Relativity. To estimate this you have to employ the difference between the rest mass M_o and the relativistic mass at the particular spacetime event when you are measuring the body, M_e. This gives us the rather elaborate proposition

$$z = \sqrt{\frac{1 + v/c}{1 - v/c}} \cdot \sqrt{\frac{1 - 2GM_e/c^2r}{1 - 2GM_o/c^2r}} - 1. \qquad (4)$$

Now, if you turn back a page or two, you will see that from equation (1) we can talk about this in terms of a black hole where M is the mass of a black hole; we shall call this the Schwarzschild mass, M_s. It is convenient to regard r in (4) as a radius for the body which is half diameter D in equation (1).

What happens then to light reddening as the accelerating body increases in mass and thus gravity from an observer's point of view? As M_e approaches M_s, redshift z should itself increase infinitely and ultimately become inaccessible to any system of measurement.

A further interesting phenomenon would be the influence of gravity 'events' induced by this effect; e.g., white dwarfs and pulsars becoming Relativistic Black Holes. The wavefronts of these 'events' would be induced so far from their source that they would appear to influence the entire galaxy over a very short space of time.

As quasars appear to satisfy many of the above requirements I

shall venture the postulate that they are in fact objects of galactic dimensions, perhaps fairly ordinary galaxies. They are so distant that they are visually distorted and endowed with apparent abundances of energy arising from the RBHs induced by their rapid cosmological recession from us.

Remember that these objects are not true black holes. They have no singularities. Furthermore, from their cosmologically remote perspective *we* would be part of a quasar.

There is an interesting rider to this in reference to Olbers' Paradox. If quasars are more or less ordinary galaxies then the Steady State theory or something approximating to it would have to hold true. In this case we would have the paradox which (more or less) asks why the night sky is dark when there are so many billions of galaxies with billions of stars belting out all that light. The two current explanations are: firstly, at great distances the light is redshifted out of the visual spectrum (in which case what about the ultraviolet which is then supposedly redshifted into it?); and, secondly, most objects in the Universe are so distant that their light has not yet reached us (in which case the Universe is not infinite in time). The alternative explanation which I put forward is that the stars, and eventually the galaxies themselves, become Relativistic Black Holes from which their light simply cannot escape to us.

Having happily worked out that my spaceships might escape the

Fig. 4: E is a relativistic gravitational event observable at cosmological distances only by its effect on light wavecrests photons. Relativistic gravity generates such events with a source E at distances such as 1, 2, 3, 4, 5, 6 etc. A is too close for a relativistic gravity event at this distance (broken line) but if A were moving fast enough it would occur and the visual result would appear to happen to the image of the Galaxy as a whole very rapidly, creating a temporary distortion.

restriction of lightspeed by turning themselves into RBHs I set about trying to figure out just how it would work out in fact or, rather, in science fiction. The results left me with an interesting hypothesis but some rather awkward angles to negotiate. Fig. 5 is an illustration of what I mean.

Accelerating at one *g* all neutron stars after some five hundred or so years have become Relativistic Black Holes, as have the majority of other stars by seven thousand years, Earth-type planets by twenty million years. So what about my starship, assuming it weighs about five thousand tonnes and is about twenty metres in

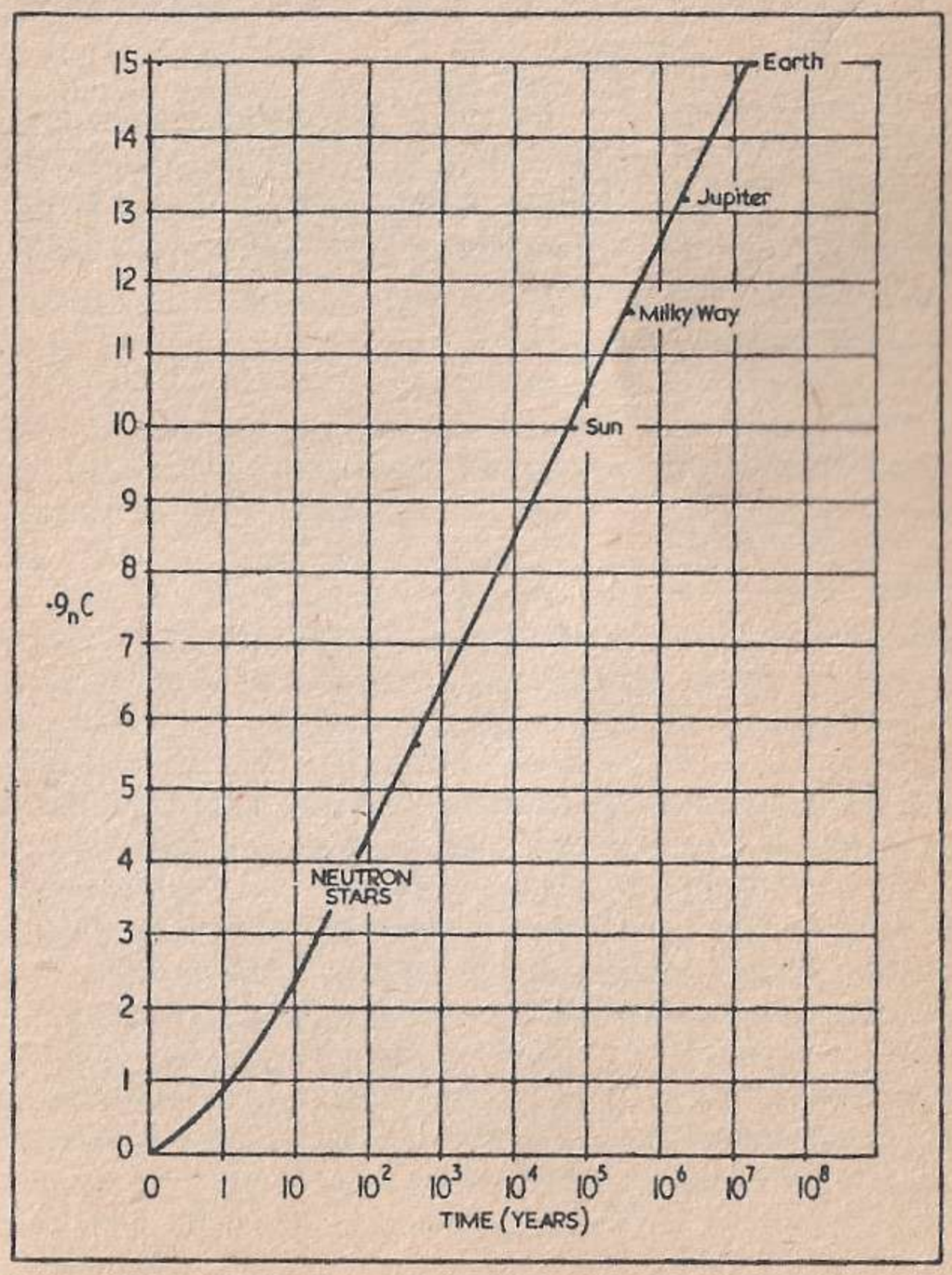


Fig. 5: Relativistic velocities attained by 1*g* acceleration against given time.

diameter? It is powered by the wondrous Boycian Field Propulsion System (patent pending) at one *g*. Sadly, it would appear that it takes rather a long time to become an RBH by this method. It takes literally many hundred million billion billion billions of years. The trouble lies in the fact that the velocity, mass and time involved work out as expressions of the energy involved in an object becoming a black hole. To circumvent time I will accelerate at many hundred million billion billion billion *g* and pop out of our Universe in less than one year.

Needless to say, if I want that kind of energy on tap my spaceship will have to be powered not by nuclear reaction (even matter annihilation will not suffice) but by the only possible source – a black hole.

Well, this is where we came in...

The above is typical of the kind of speculations which make life so much fun for the science-fiction writer and they should really be regarded in this light. Nothing in this Appendix should be thought of as being other than the musings of an amateur cosmologist with an eye to the main chance.

Appendix 3

The Interstellar vN Spaceprobe

In a society where self-reproducing automata are commonplace such as is indicated in Chapter 5 we might expect presently understood constraints on the financial basis for pure scientific research to alter drastically. This would allow projects once regarded as prohibitively expensive to be attempted, such as interstellar exploration.

Let us assume that it is deemed timely to initiate a programme of exploration of those stars lying within a range of fifty light years using technology similar to that proposed in the British Interplanetary Society's Daedalus report. A technique like the one outlined in Chapter 8 could be utilised and extended. There are roughly one thousand stars within the exploratory radius above. A vN 'egg' would be constructed by our descendants, complete with the instructions for mounting the great enterprise. The 'egg' would develop into a system for producing von Neumann machines which would in turn manufacture yet more von Neumann machines. These vN would attempt to reproduce optimally. Instead of one machine always working on total reproduction of itself it would become increasingly specialised. Let us say that the first machine takes one year to produce one vN. Both of these work together turning out the third vN in half a year. The three then make the next one in four months and the next machine is ready three months after that. Total time taken is only one month longer than the time it would normally have taken to produce four machines, but this way we have five. Using this technique we would have seventy-nine vN after five years instead of thirty-two.

The main problem with this optimised exponential growth is the logistics involved, ensuring the right materials are available where they are needed when they are needed. This problem would be particularly sticky where extremely rare materials were sought after, perhaps requiring the demolition and processing of several asteroids or Jovian type moons for a one thousand-strong fleet of interstellar craft with a payload one hundred times greater than that of Daedalus aboard each. The description of such a vehicle would give even the most speculative mind a good boggle. Each craft would have a mass of around $1{\cdot}4 \times 10^{11}$ tonnes, one hundred and forty billion tonnes!

And the mass of the fleet would be one hundred and forty thousand billion tonnes!!

Most of this will be in the form of fuels extracted from Jupiter, principally helium-3 and deuterium. The expected abundance of these isotopes might be low but that of the elements is high, the planet consisting of hydrogen and helium mostly. In fact there should be in the region of 10^{23} tonnes of deuterium and 10^{16} tonnes of helium-3 distributed throughout the planet which means that the fleet of one thousand ships would barely scratch the resources there.

A vN has the theoretical capability of being able to do anything that any other machine can do even if this means building another machine as an extension of itself. The Daedalus group reckoned on a twenty-year completion time for their interstellar probe. If we assume the same for a vN's timetable to build a Daedalus, then we should reckon on it taking one hundred times longer to build a vN type probe, two thousand years, and as the fleet numbers one thousand this would mean one vN would take over two million years to build the fleet. This, however, is only the tip of the problematic iceberg. Most of the fleet's mass is comprised of fuel at launch and obtaining it requires the construction of fleets of atmospheric extraction and processing plants. The Daedalus study budgeted for the production of eight of these per year and one hundred and twenty-eight of them to fuel the probe. Considering the mass of the fleet this would require more than three hundred and fifty billion extraction/processors which would take our single vN something like four and a half billion years to produce – which is the present estimate of the age of the Solar System. To produce that many in a single year, however, requires that we have four and a half billion vN, a number which we can attain by optimised exponential reproduction in around a mere seventeen years!

But the logistics will be the real bitch here. Aiming at a launch-date around half a century after the first 'egg' is put to work is probably more realistic, so the cost of the exploration of the one thousand nearest stars would be the cost of the 'egg'.

It is important to stress that the main missions would be similar to those of our present-day interplanetary probes and geared to exploration and the pursuit of scientific knowledge. The CETI consideration is very secondary as it is on the Pioneer and Voyager probes with their CETI packages. It would, of course, become the overriding element in the long term.

On arrival at their one thousand target stars the vN would lay their 'eggs' and the whole process of producing another thousand would begin, the second 'generation'. By the fourth such generation's reaching their target stars, our Galaxy, the Andromeda Galaxy and the satellite 'clouds' will have been

colonised by vN spaceprobes. Given their capabilities it seems reasonable to suppose that they will evolve with time and as this factor too could be optimised they would be streamed along a path which enhanced their chances as successful CETI messengers in the long term.

Obviously if another lifeform has emerged before us in the cosmos and wished to leave some cultural legacy to those emerging after it this would be an appealing strategy. In fact, some rough estimates as to a horizon for this phenomenon can be judged in terms of a SETI search today. As these machines have a potentially vast lifespan, they would not have to rush helter skelter about the universe. There should be no great need for them to travel above 20% lightspeed. This means that if, miraculously, one had begun its spread across the stars at the very moment the Big Bang banged it could have travelled no further than four billion light years. If we adopt a more modest but still generous margin for the appearance of intelligent life at five billion years ago and assume the first vN probes could have been released no earlier then we can say with some confidence that should one have been released within a billion light years of our own Milky Way Galaxy there is a better than even chance that one of its brood is somewhere in our Solar System right now.

This radius takes us close to the very fringes of the galaxies which can be viewed by optical techniques at all.

Even if technological life is commonplace amongst the stars and beings communicate by other methods, there must still have been some point at which the first technologies emerged isolated in time and space. They would have been sorely tempted to release vN CETI markers surely.

Either way the chances of their being in the Solar System at present must be regarded as being extremely high.

Appendix 4

Tomorrow and Tomorrow: A Glance at the Future

When we are confronted with indisputable evidence for ETI we may have to face a society which was once like our own but has advanced considerably on our comparatively primitive condition. What is more likely is that our society will at some point in the future face a very unusual form of AML originating off the Earth. In either case, we should take a look at the future to imagine the possible contexts.

I will run through some projected developments for the next couple of centuries. I will be drawing heavily on three particular works for this: *The Next Two Hundred Years* by Herman Kahn; *Profiles of the Future* by Arthur C. Clarke; and *Tomorrow's World* by Raymond Baxter.

By 1985: Clandestine proliferation of nuclear weapons. Spectacular multinational degradation of the environment. Sophisticated surveillance and control of public behaviour. Widespread unemployment rising with inflation. Choice of sex for babies becomes moral issue. Cannabis and other mood-influencing drugs more readily available and less unacceptable. First child born outwith the womb. Large-scale internal warfare in Africa has begun. Regional technological catastrophes.

By 1990: Human cloning is possible. Highly efficient electrical storage systems. Cancer conquered. Permanent prosthetic devices grafted into human bodies. Brain enhancement by drugs. Fusion becomes viable. Cheap synthetic food.

By 1995: Cold cure and other anti-viral measures. Tremendous increase in wealth over past two decades particularly in Third World but proportional differences in wealth distribution. Nuclear terrorism widespread. EEC reshaping into a new Euro-community dominated by France. Possible estrangement of Eastern European countries from USSR and formation of their own trading/security grouping. New arms races as some Third World countries such as Brazil become major suppliers of arms in competition with 'developed' countries. USSR becomes increasingly subjectively oriented as domestic problems multiply. Commercial fusion operational as an energy source. Global computer links for home computer terminals.

By 2000: Inflation ('the poverty of affluence') mitigates against the cutting of the already record levels of unemployment. Minority agitation groups outlawed. High surveillance of ethnic and cultural minority groups as well as banning of many fringe political activities in the 'developed' countries. Two-way Brain-Drain where cheap-labour unemployed come to work for low wages in 'developed' countries and are replaced in the Third World by high-skilled unemployed from the West. Gross National Product averages out at $1000 per capita worldwide, but the figure disguises vast inequality of distribution. Tactical nuclear weapons have been used in limited warfare. Erosion of many traditional values among the educated throughout the world. Voluntary euthanasia. Sub-ice city in Antarctica. Genuine artificial intelligence. Full interface established between the human brain and the computer. Manned expedition to Mars. Permanent lunar stations and large orbiting space stations with workshop facilities. Beginnings of space industrialisation. Alliance of 'developed countries' in Fortress North against developing Third World. Some countries adopt compulsory birth control. More food, including a good proportion of synthetics, becoming readily available throughout the world. Sea and seabed mined for minerals.

By 2025: Interstellar probe under way. Orbital power stations. Large-scale space industrialisation. Santa-Claus Machines, self-reproducing factories which can manufacture almost anything when given the specifications. Complex issues being handled increasingly by humans with machine-enhanced brains. Computer-linked sensory extensions of the nervous system. Commercial fusion widespread as are non-depleting energy machines. Conservative backlashes developed to the erosion of traditional values. Emergence of 'educated incapacity' among post-industrial intellectual élites producing illusioned, irrelevant, ideologically exotic and impractical argument and attitude. Mutually conflicting cultural developments appear with a world-wide spread, resulting in 'mosaic cultures'. Crumbling of Fortress North as a viable concept. Law and order become a global problem. Possible emergence of agencies like Orwell's Thought Police. Genetic choice of child's general characteristics. Experimentation in nuclear synthesis of materials. Multicorp combines and alliances wield greater power than any national government.

By 2050: Virtually all energy comes from fusion and non-depletable resources. Design and construction of vN. International commuter system on land/sea/underground operating super-

sonically. Fully integrated man-machine systems tailored to one another appear. Average IQ rises dramatically world-wide. Human-artificial intelligence Hybrids take on many major decision-making tasks. Explosive colonisation of space taking place. Gaps between wealthy and not-so-wealthy narrowing noticeably. 'Educated Incapacity' becomes major stumbling block to problem-solving due to overemphasis on theory much of which has no practical application, and even where it has, there is not enough work experience to fall back on. Widespread use of electrochemical mind enhancement, memory transplanting and relaying, and electronic telepathy as a communication device. Nuclear synthesis of materials operating commercially. Animals with genetically raised levels of intelligence. Experiments with gravity control.

By 2100: Political powers are (1) Multicorps based in Inner Planet space, and (2) Multicorps based on Callisto and dominating asteroid belt. Human race clearly splitting into two groups, the humans and the Hybrids. latter have launched first interstellar expedition. Terrestrial food supplies greatly increased due to factory-produced synthetic foods, reclaiming of land from inhospitable areas, desalination of sea water and sea farming. Total weather control is in sight. Santa-Claus machines provide wide ranges of 'free' goods. Individual humans becoming more involved with communities and small-scale events and dissociating from the organisation society. Mechanical instant education. Global computer teaching-library. Hybrids form first real think-tank by joining to formulate first true superintellects. Astronomical engineering projects are possible. Hybrid immortality is assured.

By 2150: Humans are on the wane as population begins to drop dramatically. Hybrids undertake large-scale social engineering of humans. A new hybrid – the Hybrid/dolphin hybrid – achieves the long-awaited comprehension of the cetacean mind. From this comes enhancing of the cetacean brain and links thereto. Differences in wealth are still evident but no longer important. New taboos and intellectual cults abound. Politics of the industrial societies of the two previous centuries is virtually obsolete. Politics is more community-oriented. Traditional states exist as technicalities. Multicorps employ virtually no one and are run by Hybrids with vanishingly small human involvement.

By 2180: Social engineering, the excising of unwanted characteristics, is almost completed amongst both Hybrids and 'humans'.

Immortality for 'humans' assured. Hybrids begin world laboratory experiments on Venus.

Most of the above is my own interpretation of the sights seen in the smoky mirror and should not be laid at the doors of others. The other alternative futures can be summed up fairly briefly:

(a) Thermonuclear war: a massive debacle which plunges us back well over a hundred years at worst but at best results in merely a temporary halt of a few years (or perhaps even an incentive to increase in peaceful nuclear technology).

(b) Environmental catastrophe: the regional catastrophes which will become common before the end of the century will not have set up a sufficent control backlash to avoid a terminal situation again resulting in massive death and destruction. At worst this might set us back a hundred years, if we survived at all. Energy crises becoming explosive situations could lead to either this or (a).

(c) Graduated growth: this entails heavy restrictions to modify social impact and extends the above scenario of two hundred years by a further century.

(d) Zero growth: small-scale technological society with very low growth rate. Altruistic anarchism is the main political base for social structures. Extend above scenario by five hundred years to infinity. No crises other than on the very small scale should arise.

Notes

Prologue

1. Alvin Toffler is the author of *Future Shock*, a book which all students of ET Encounter situations should read. Toffler is concerned with the rising rate of change to which the individual is becoming exposed and the inadequacy of most to cope with it.
2. *Glasgow Herald*, 21 November 1977, 'Inside America' column, p 2.
3. 'Second BIS Conference on Interstellar Travel and Communication', K. W. Gatland, *BIS Journal* vol 30, no 12, December 1977.
4. This, of course, is how the Sun does function. Hans Albrecht Bethe demonstrated this satisfactorily in 1938.
5. Two editions of Koestler's *Act of Creation* have appeared. This quote comes from the earlier non-definitive one.
6. *The Psychology of Imagination*, Jean-Paul Sartre, p 20, Methuen, London, 1972.
7. *Ibid*, p 60.
8. *The Hollow Men*, T. S. Eliot, 1925.
9. *The Cosmic Connection*, Carl Sagan, p 42.
10. Extraterrestrial vampirism goes back to Wells' *War of the Worlds*. Here the Martians ingested nourishment in the form of human blood directly into their own bloodstream. The movie in which a green lady puts the bite on us Earthies is *Queen of Blood*.
11. This film is a prime example of one particular Hollywood SF cliché. Human beings are replaced with duplicates similar in all respects but for the absence of any emotions; a reflection of Wells' 'cool, unsympathetic intellects'.

Chapter One Historical Perspectives 1

1: *Homo erectus* of a million or more years ago would certainly have had the basis for cultural exchanges. These people were stone technicians and as such had the basis for the interchange of technology. Designs of chisels, axes, anvils, etc., as well as novel techniques in using them would probably be valuable in such communities. There may even be evidence to suggest that cultural activity could have pre-dated *Homo* himself. See 'Evidence for Social Custom in Wild Chimpanzees' in *Man* vol 13, no 2, pp 234–251.

2: This is a very interesting if highly personal interpretation of history. It is valuable for the highlights which it offers on matters arising out of intercultural contact. Toynbee is generally regarded as an 'historicist', one who seeks to show general laws operating within the process of history. Karl Popper, the philosopher, argues strongly against this interpretation of history.
3: Strangely enough, no one has used the analogy with respect to what appears to be the worst example of destructive intercultural consequences. The natives of Tasmania suffered a population collapse when exposed to the West, to Britain in fact. Within one generation the 30,000 native inhabitants of the island were reduced to a few hundreds. They are now extinct.
4: The notion that European technology was totally alien to the native Americans is false. In the early struggles along the Americas' North Atlantic seaboard the natives proved this decisively. Not only did they learn how to run ships-of-the-line, on one notable occasion they displayed their command of naval tactics by soundly defeating British warships in a maritime engagement (1724, off the coast of New Hampshire).
5: It is only more likely because we can now be heard in terms of radio in an area comprising less than one hundred and twenty-five billionths of the Galaxy's volume whereas, before, we were heard over still less.
6: This transformation was mainly carried out within the fifty years from 1855 to 1905, although some fundamental rethinking did take place between 1945 and 1948/50.

Chapter Two Historical Perspectives 2

1: *The Neophiliacs* by Christopher Booker is a study of the personalities and attitudes which made the swinging 'sixties swing.
2: No doubt gimlet-eyed Scots Nationalists will be scrutinising any possible bias, for example the setting up of a St George's Society.
3: *The Ascent of Man*, Bronowski, p 437.

Chapter Three The Dark Pedigree

1: The Encounter Equation is not strictly mathematical but, if we are to regard it as an equation at all, it is best to establish some form of mathematical expression of it. We will represent the complex function Man as *M* and the complex function which is the ETI as *E*; human aspects not shared by the ETI we shall designate *x* and ETI aspects which are not shared by humans

we shall term y. This gives us an 'encounter equation' as follows:

$$M - x = E - y.$$

$\therefore$ where $x = 0$ *or* $y = 0$, then $M < E$ or $M > E$, respectively, in terms of mental capability. Where both x and $y = 0$ then $M = E$; we are virtually identical with the ETI in terms of mentation.
2: A list of the forty-two interstellar molecules discovered up to early 1977 can be found on p 269 of *The Cambridge Encyclopaedia of Astronomy*.
3: Life is estimated to have existed in some form or another on Earth for more than three billion years; however, the pre-biological processes which produced terrestrial life may also have been singular. If this is so, then we can expect the fundamental structures of organisms to have differing 'architecture' even if they have the same 'building blocks'.
4: Here I am referring to the excellent examination of the rise of human technical civilisations by Richard Lee of Toronto University's Anthropology Department in *Communication with Extraterrestrial Intelligence: CETI*, edited by Sagan. This tells us a great deal about ourselves but from ourselves alone we can say nothing about other mental life in the Universe. We can certainly not assume that other mental life has civilisation or technology. All we can say is that if they have technology as we appreciate it there is a chance that they have civilisation, and vice versa. What the chance is nobody knows. Generally it must be regarded as suspect to assume that in the Encounter Equation (see Note 1 above) it is likely that x will be near zero.
5: These experiments in simian language capabilities took place respectively at the University of Nevada and the Yerkes Primate Center, Emory University, Atlanta.
6: There is a rumour afoot at the time of writing that an optimistic conservation group intends setting up just such an embassy in Sydney harbour.
7: Ian Watson's *The Martian Inca* is particularly interesting in this context; and his *The Jonah Kit* has an especial interest in interaction of human and cetacean thought processes.

Chapter Four Come Up and See Me Sometime

1: The term 'biogrammar' was coined by Fox and Tiger and used in their joint work *The Imperial Animal*.
2: The hypothesis that all organisms interact in such a way as to

maintain Earth as a fit habitat for life is called the *Gaia* hypothesis after the Greek goddess of the Earth who gave birth to the sky, mountains and sea. Its concept originated with James Lovelock, an analytical chemist, and has since found another champion in the person of Lynn Margulis, a cell biologist at Boston University.
3: *Star Trek* was selected here in preference to the great number of other TV science fiction series because it was consistently better than most others and, where others *were* better, they did not have as large an audience.
4: Of course there is no way of knowing the motive behind an ETI's behaviour on first contact; consequently it will be impossible to judge just how effective whatever method of behaviour manipulation it chose might prove to be.
5: Of course there is always the remote (I hope) possibility that instant panic will prompt us to send a hailstorm of nuclear warheads out upon the visitor.

Chapter Five A Meeting With Tomorrow

1: Teilhard de Chardin, *The Phenomenon of Man*.
2: Here I must mention the Committee for the Scientific Investigation of Claims of the Paranormal. This is an organisation of highly qualified sceptics, exactly the kind of body which the pro-paranormal community needs. They provide novel and always relevant methods whereby paranormal claims are disproved. Only when they have been satisfied that the paranormal exists will the rest of society really take it seriously.
3: This is not intended in any way as a teleological statement. Our 'direction' may change causing us to head towards a different 'point'. There is nothing to suggest that any point on the horizon is the destined end towards which we are being drawn or driven. In evolutionary terms it is better to regard the horizon as we regard the horizon in the world about us: it is merely a limit on our vision, and points exist beyond it which we cannot see.
4: Like H. G. Wells' *First Men in the Moon* this book examines extraterrestrials which have a biological caste system rather similar to that of the social insects. It is an extremely interesting investigation of this type of society.
5: The imaginary wars portrayed in this and other works are critically considered in J. F. Clarke's *Voices Prophesying War 1763–1984*.
6: Although this book is concerned with the future of Man rather than the ETI it is probably one of the most effective US novels

produced since the Second World War. I cannot recommend it highly enough.
7: Wiener, a distinguished mathematician, brought the word into common currency when he published his book *Cybernetics* in 1948. The term is derived from the Greek word *kybernetes* for 'helmsman'.
8: For a survey of the arguments and history associated with this tender topic see *The Human Pedigree*, by Anthony Smith.
9: *Datamation*, no 2, April 1972, p 8.
10: Whether or not such machines ever appear seems to depend (at least presently) upon our deciding to permit their existence, as it is we who must set the self-improving system in motion primarily.
11: Man appears to employ tools to help him accomplish predetermined ends. For this reason I see the amplification of human intelligence by direct interface with machines as inevitable, but artificial intelligence as merely possible.
12: J.D. Bernal and Columbia University physicist Gerald Feinberg have, however, speculated to some extent upon it and concluded that, as the network of minds can be amplified, no mind need ever be totally lost, even through death!

Chapter Six Saucers and Dishes

1: Anyone quite new to the subject is particularly directed to Ian Ridpath's two excellent introductions – see the Bibliography.
2: *The Cosmic Connection*, Sagan, p 203.
3: It really is important to state that at the time of writing there is no reason to believe that there were advanced technical human civilisations in the past (i.e., capable of handling energy in the quantities which we can today) or that we have ever been visited by ETIs. All evidence in support of such claims has been at best ambiguous.
4: This was discovered by mining engineers in the Gabon a few years back. Luckily for them it had been extinct for several million years. See *Encyclopaedia Britannica* supplement 1978.
5: M.W. Saunders mentions the possibility of living databanks in his 'Databank for an Inhabited Extra-Solar Planet'. This is a survey of databank options open to a human interstellar expedition. *BIS Journal*, vol 30, pp 349–358.
6: Shklovskii's speculation that the Martian moon Phobos might be artificial was mistaken but a fascinating description of the possibility can be found in *Intelligent Life in the Universe*, Shklovskii and Sagan, pp 363–376.

7: 'Communications from Superior Galactic Communities', *Nature*, vol 186, 1960, p 670.
8: The BIS Daedalus study is particularly interesting in this respect. It examines the possibilities of sending a probe some two parsecs from our Solar System to that of Barnard's Star using existing and foreseeable technologies.
9: Published in English with Carl Sagan's contributions as *Intelligent Life in the Universe*.
10: To be more precise, he is seeking out the characteristic radiation which would be emitted from a Dyson sphere or shell.
11: It has been suggested by P.V. Makovetski, of the Leningrad Institute of Aviation Instrument Manufacture, that perhaps the best plan for detecting a technical civilisation would be investigating wavelengths which were significant in terms of mathematical and physical constants (such as π and the square root of 2). 21 cm divided by π, for example, is 6.68 cm.

Chapter Seven Past Contact and the Moving Caravan

1: Duncan Lunan, *Man and the Stars*, Souvenir Press, London, 1974. US edition: *Interstellar Contact*, Henry Regnery Co., Chicago, 1975.
2: A.T. Lawton & S.J. Newton, 'Long Delayed Echoes: the Search for a Solution', *Spaceflight*, vol 16, no 5, pp 181–187 (May 1974).
3: C.G. Jung, *Flying Saucers: a Modern Myth of Things Seen in the Skies*, translated by R.F.C. Hull, Routledge & Kegan Paul, London, 1959.
4: Christopher Evans, *Cults of Unreason*, Harrap, London, 1973.
5: Carl Sagan, *The Cosmic Connection*, Doubleday, New York, 1973.
6: Zdenek Kopal, *Man and His Universe*, Rupert Hart-Davis, 1972.
7: Edward Purcell, 'Radioastronomy and Communication through Space', in *Interstellar Communication*, ed. A.G.W. Cameron, Benjamin, New York, 1963.
8: 'Eye on the Future', *Nature*, vol 241, 1973, p 363.
9: Eugene F. Mallowe, review of *Interstellar Communication: Scientific Perspectives*, *Journal of the British Interplanetary Society*, vol 28, no 3, pp 223–224 (March 1975).
10: Gerald M. Webb, review of *Interstellar Communication: Scientific Perspectives*, *Spaceflight*, vol 17, no 4, p 158 (April 1975).
11: Ronald Story, *The Space-Gods Revealed*, New English Library, 1977.
12: I.S. Shklovskii & Carl Sagan, *Intelligent Life in the Universe*, Holden-Day, 1966.

Chapter Eight Meditations of the Heart

1: 'Advanced life in the Universe', by A. Cottey in *New Scientist*, 27 April 1978, p 236.
2: Paul Davies, of King's College, London, makes this suggestion in *The Runaway Universe*, p 101. It is interesting to note that the concept of biological spaceships has been tackled by science-fiction writers, notably in James White's 'Spacebird'. There is also Larry Niven's interstellar lifeform the starseed, which appears in 'Grendel'.
3: This, to be fair, is generally regarded as the upper limit for the possible emergence of Advanced Mental Lifeforms.
4: I first came across this concept in Michael Arbib's article 'The Likelihood of Evolution of Communicating Intelligences on Other Planets', contained in Ponnamperuma and Cameron's *Interstellar Communication: Scientific Perspectives*.
5: John von Neumann died in February 1957. The last year of his life was a tragic race against the bone cancer which agonised and exhausted him. It was a race to try and complete as much work as was physically and mentally possible by a man who had so much to give. An account of it by his wife can be found prefacing his last (unfinished) work *The Computer and the Brain*.
6: The BIS Daedalus study shows the promise of pulsed nuclear fusion for propelling interstellar vehicles. At the time of writing we are still several decades removed from the point at which we will sit down to the actual designing of such a craft; consequently we can imagine that numerous other and perhaps better propulsion system possibilities will become more readily accessible to Man.
7: Theodore Taylor of the International Research and Technology Corporation theorises that a 'Santa-Claus Machine' might be possible, a machine which can literally build anything which it is programmed to build – including other 'Santa-Claus Machines'. Such a device would be very attractive for the core of a human vN system.
8: The most notable entries in this encyclopaedia can be found in Isaac Asimov's *Foundation* trilogy.
9: This can be found in Anthony Lawton's 'Long Delayed Echoes – The Trojan Ionosphere', in the December 1974 issue of the *BIS Journal*.

Chapter Nine Unbelievably Fatuous Observations

1: These are:

CE1K: no lasting trace of interaction between the UFO and the environment, nor with the reporting observer(s).

CE2K: observable traces of reported interaction remain subsequent to UFO report.

CE3K: reports referring to observations of animated occupants of UFOs.

See J. Allen Hynek's *The UFO Experience*.
2: Two interesting books which deal with gullibility and irrationality are Patrick Moore's *Can You Speak Venusian?* and Christopher Evans' *Cults of Unreason*.
3: An interesting examination of the evidence for fairies is in Robert Sheaffer's 'Do Fairies Exist?' in the Winter 1977 issue of *The Zetetic*. More recently, Summer 1978, the same magazine published an examination of fairy photographs using computer enhancement to illustrate their fakery.
4: See Ian Ridpath's *Messages from the Stars*, p 211 for a description of investigations by A. H. Lawson of California State University.
5: Jung's Book *Flying Saucers: A Modern Myth of Things Seen in the Skies*, interprets the UFO phenomenon strictly within the terms of theoretical psychology.
6: This frightening thought process probably did occur. That official circles were more trepidacious of UFO reports than UFOs themselves is made abundantly clear in David Michael Jacobs' *The UFO Controversy in America*. P 83 specifically quotes a Robertson panel finding that such reports made the public vulnerable to psychological warfare.
7: This author's book *The Real World Of Spies* is a classic of espionage writing.
8: A report on this appeared in the *Inside France* column of the *Glasgow Herald*, 25 October 1977, p 2.
9: It may just be that Scotland is in the middle of a UFO 'spasm' coincident with my writing. Newspaper reports of sightings on or around my native soil rose sharply between summer 1977 and spring 1978.
10: See *Spaceflight*, June 1976, for Peter Glaser's 'Development of the Satellite Power Station', and the same magazine for March 1977 giving the Boeing Company's concept considerations in 'Powersat'.
11: I am not alone in believing that we cannot yet dismiss the possibility of Martian life. Robert Jastrow, founder and director of NASA's Goddard Institute for Space Studies is also of this view. See his book *Until the Sun Dies*, pp 154–163.

Chapter Ten Them

1: The stories of James White in this series alone should be required reading for exobiologists in training. He also has written a most interesting and instructive article on 'Biologies and Environments' in Brian Ash's *Visual Encyclopaedia of Science Fiction.*
2: Sneath's book *Planets and Life* probably gives the best introduction to the life-sciences aspect of the subject of ETI. It is a wide-ranging lucid work and comes highly recommended.
3: Royce's article 'Consciousness and the Cosmos' is contained in *Extra-Terrestrial Intelligence: The First Encounter* edited by J. L. Christian. This volume contains a number of valuable philosophical essays on the subject, notably Royce's and those of Peter Angeles and Wilfred Desan.
4: This is an aspect advanced by Wilfred Desan (see note 3).

Chapter Eleven High Society

1: The story that Fermi, the great nuclear physicist, was supposed to have put this question over a luncheon in 1940 is possibly apocryphal, according to Carl Sagan in *The Cosmic Connection*, p 229.
2: *The Galactic Club* is actually the title of his excellent book on CETI.
3: This is probably the most exhilarating text in the entire field and not to be missed on any count by layman or professional!
4: This term was created by the Canadian communications philosopher Marshall McLuhan to describe the intimacy possible on a world-wide scale through supersophisticated electronic communications.
5: *The Ghost in the Machine* is Koestler's main treatment of this point.
6: Alan Cottey of the University of East Anglia warns of the danger of trying to separate the intelligence from its artefacts (Chapter Eight, note 1). This would certainly be the case for Man when he ever achieves this status. There will either be the situation where we must view our artifacts as actual parts of the human or we must view what we have by then become as being human no longer.

Epilogue What Do You Say Before You Say Hello?

1: How close the supernova would have to be is not quite certain but, if a supernova occurs within our Galaxy once every century

(generally in areas obscured from us by thick dust clouds), there should have been one for every hundred or so stars. It takes several hundred thousand years for the shockwave to peter out and, after the first century, it is still expanding at some 10% of light speed. For further details see 'A Supernova Trigger for the Solar System?' by D. Paterson in *New Scientist*, vol 78, no 1102, pp 361–363, 11 May 1978.
2: James Gunn's novel *The Listeners* should be compulsory reading for anyone involved in the funding of SETI programmes. It is a story about the first signal picked up from another star system after many decades of waiting, during which the project has degenerated into a minor financial/political chesspiece.
3: Tom Norton, Conservative MP for Cheadle, made these claims with reference to Concorde machine tool manufacture and design in the European Parliament at Strasbourg. *Daily Telegraph*, 9 July 1975.
4: The 1976 report commissioned by NASA from Chase Econometrics Associates Inc.; see 'Does Space Research Help US Economy?' by Roger Levis in *New Scientist*, vol 77, no 1096, p 838, 30 March 1978.

Bibliography

This is not a bibliography in the sense of a complete listing of works relevant to the subject matter of the book. My own feeling about CETI is that it is a subject of *fundamental* importance because so many diverse elements of human thought are involved here. What follows are two booklists. The first deals with non-fiction and the second with science fiction. The first is a selection of works which I hope illustrates the main arguments within CETI and the fields which I believe are essential to a study of it. The asterisked works might prove useful to newer readers in the field.

History:

Carr, E. H., *What is History?*, Macmillan, London, 1961*

Durant, Will, *The Story of Civilization* (32 vols), Simon & Schuster, New York, 1935, 1963*

Roberts, J. M., *The Hutchinson History of the World*, Hutchinson, London, 1976

Toynbee, Arnold, *A Study of History* (single volume edition), Oxford University Press with Thames and Hudson, London, 1972

Science and Philosophy:

Bronowski, J., *The Ascent of Man*, B.B.C., London, 1973*

Dobzhansky, T., *The Biology of Ultimate Concern*, New American Library, New York; Fontana/Collins, 1967

Duncan, Ronald and Miranda Weston-Smith (eds.), *The Encyclopaedia of Ignorance*, Pergamon Press, London, 1977

Koestler, Arthur, *The Act of Creation*, Hutchinson, London, 1964

Koestler, Arthur, *The Ghost in the Machine*, Hutchinson, London, 1967

Koestler, Arthur, *Janus, a Summing Up*, Hutchinson, London, 1978

Koestler, Arthur, *The Sleepwalkers*, Hutchinson, London, 1959*

Magee, Bryan, *Popper*, London, Fontana/Collins, 1973

Monod, Jacques, *Chance and Necessity*, Collins, London, 1972

Teilhard de Chardin, P., *The Phenomenon of Man*, Harper, New York; Collins, London, 1959

Teilhard de Chardin, P., *The Future of Man*, Harper, New York; Collins, London, 1964

Behaviour:

Ardrey, Robert, *The Hunting Hypothesis*, Collins, London, 1976*

Friedrich, Heinz (ed.), *Man and Animal*, MacGibbon and Kee, London, 1971

Leakey, Richard E. and Roger Lewin, *Origins*, Macdonald and Janes, London, 1977*

Lorenz, Konrad, *Behind the Mirror*, Methuen, London, 1977

Lorenz, Konrad, *On Aggression*, Methuen, London, 1966

Pfeiffer, John E., *The Emergence of Man*, Harper & Row, New York, 1969; Thomas Nelson, London, 1970*

Tiger, Lionel and Robin Fox, *The Imperial Animal*, Secker & Warburg, London, 1972

Wilson, Edward O., *Sociobiology: The New Synthesis*, MIT Press, Cambridge, Mass., 1975

Astronomy:

Asimov, Isaac, *The Universe*, Penguin Books, London, 1967*

Davies, Paul, *The Runaway Universe*, Dent, London, 1978*

Gribbin, John, *Our Changing Universe*, Macmillan, London, 1976

Jastrow, Robert, *Until the Sun Dies*, Souvenir Press, London, 1978*

CETI:

Asimov, Isaac, *Is Anyone There?*, Doubleday, New York, 1967*

Bracewell, Ronald, *The Galactic Club*, W.H. Freeman, New York, 1975*

British Interplanetary Society, Journal of, 'Final Report of the Project Daedalus Study Group', *Supplement*, 1978

Christian, J.L. (ed.), *Extraterrestrial Intelligence: the First Encounter*, Prometheus Books, Buffalo, 1976

Lunan, Duncan, *Man and the Stars*, Souvenir Press, London, 1974; as *Interstellar Contact*, Henry Regnery, Chicago, 1975*

Maruyama, M. and A. Harkins (eds.), *Cultures Beyond the Earth*, Vintage Books, New York, 1975

Ponnamperuma, Cyril and A.G.W. Cameron (eds.), *Interstellar Communication: Scientific Perspectives*, Houghton Mifflin, Boston, 1974

Ridpath, Ian, *Messages From the Stars*, Fontana/Collins, 1978*
Ridpath, Ian, *Signs of Life, the Search for Life in Space*, Penguin Books, London, 1977*
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Stoneley, Jack and A. T. Lawton, *CETI*, Wyndham Publications, London, 1976
Stoneley, Jack and A. T. Lawton, *Is Anyone There?*, W. H. Allen, London, 1975
Sullivan, Walter, *We Are Not Alone*, McGraw-Hill, New York, 1964; Hodder & Stoughton, London, 1965

Future:

Bernal, J. D., *The World, The Flesh and The Devil* (1929), Jonathan Cape, London, 1970
Berry, Adrian, *The Next Ten Thousand Years*, Jonathan Cape, London, 1974
Bundy, Robert (ed.), *Images of the Future: The Twenty-First Century and Beyond*, Prometheus Books, Buffalo, 1976
Calder, Nigel, *Spaceships of the Mind*, B.B.C., London, 1978*
Kahn, Herman and others, *The Next 200 Years*, Associated Business Programmes, London, 1977
Leach, Gerald, *The Biocrats*, Jonathan Cape, London, 1970
Rorvik, David, *As Man Becomes Machine*, Souvenir Press, London, 1973*
Toffler, Alvin, *Future Shock*, Bodley Head, London, 1970

UFOs and Ancient Astronauts:

Hynek, J. Allen, *The UFO Experience*, Henry Regnery, Chicago; Abelard-Schuman, London, 1972*
Jacobs, David Michael, *The UFO Controversy in America*, Indiana University Press, Indiana, 1975
Klass, Paul J., *UFOs Explained*, Random House, New York, 1974*
Steiger, B., *Project Blue Book*, Ballantine, New York, 1976
Story, R. D., *The Space-Gods Revealed*, New English Library, London, 1977*

Temple, Robert K. G., *The Sirius Mystery*, Sidgwick & Jackson, London, 1976
von Däniken, Erich, *According to the Evidence*, Souvenir Press, London, 1978*

This second list is of science-fiction books. This is not intended as a guide to the literature. Anyone seeking such a guide would be advised to seek out such works as Brian Aldiss' *Billion Year Spree* (1973) for historical and philosophical viewpoints, and Brian Ash's *Visual Encyclopaedia of Science Fiction* (1977) for a good general introduction.

What follows is a selection of SF which should provide the reader with a wide variety of viewpoints on the ETI. It does not contain all the best ETI novels in the field and I have missed a fair number which other authors would certainly have included out of their own personal preferences. Regard it as a rough basic list. Most have gone into many editions – hence the lack of bibliographical details.

Aldiss, Brian: *The Dark Light-Years*
Aldiss, Brian: *Hothouse*
Asimov, Isaac: *The Gods Themselves*
Anderson, Poul: *The Byworlder*
Benford, Gregory: *In the Ocean of Night*
Blish, James: *A Case of Conscience*
Brunner, John: *Total Eclipse*
Clarke, Arthur C.: *Childhood's End*
Clarke, Arthur C.: *Rendezvous with Rama*
Clarke, Arthur C.: *2001: A Space Odyssey*
Clement, Hal: *Iceworld*
Clement, Hal: *Mission of Gravity*
Clement, Hal: *Needle*
Dickson, Gordon R.: *The Alien Way*
Green, Joseph: *Conscience Interplanetary*
Lem, Stanislaw: *Solaris*
Gunn, James E.: *The Listeners*
Herbert, Frank: the *Dune* trilogy (*Dune*, *Dune Messiah* and *Children of Dune*)
Hoyle, Fred: *A for Andromeda*
Hoyle, Fred: *The Black Cloud*
Lewis, C. S.: *Out of the Silent Planet*
Niven, Larry and Jerry Pournelle: *The Mote in God's Eye*
Shaw, Bob: *A Wreath of Stars*
Shaw, Bob: *The Palace of Eternity*

Stapledon, Olaf: *Last and First Men*
Watson, Ian: *The Martian Inca*
Weinbaum, Stanley G.: *A Martian Odyssey*
Wells, H. G.: *The First Men in the Moon*
Wells, H. G.: *The War of the Worlds*
White, James: *All Judgement Fled*
White, James: *Hospital Station*
White, James: *Star Surgeon*
Zerwick, Chloe and Harrison Brown: *The Cassiopeia Affair*

Index

acculturation, 22–41
Africa, 36–7
Alien Way, The (Dickson), 21
American native populations, 23, 26–7
analogy, 16–17
ancient astronauts, 75
archaeology, 76
Arecibo radio telescope, 84
Aztec, 23, 25–6

Barnard's Star, 90
behaviour, 49–59; 99 bonding, 55–9
Bell, Jocelyn, 82
Bernal, J. D., 138
biogrammar, 55–8
biological machines, 100
Black Cloud, The (Hoyle), 124
black holes, 154–62
Blish, James, 21
Bracewell, Ronald N., 78–81, 86–7 132
British Interplanetary Society, 86; Daedalus report, 90, 102
Bronowski, Jacob, 38

CETI, 46, 51, 121, 128–9, 150; past contact, 76, 95–8; radio searches, 15, 46, 51, 52, 58, 72–3, 80–1, 84, 100–1, 109–11, 129, 135, 146; spaceprobes, 78–80, 86–92, 101–111
strategies, 74–6, 99–111
Case of Conscience, A (Blish), 21
cetaceans, 48–9, 77
chauvinism, 19, 39, 92, 124
China, 34–5
Chiu, Hong-Yee, 75
civilisations, *see* ETI 'civilisations'
clan system, 36–7
Close Encounters of the Third Kind, 84, 123, 153
Cocconi, Guiseppe, 72, 85
computers, *see* machine intelligence
Cosmic Connection, The (Sagan), 133
Cottey, Alan, 106
Cults of Unreason (Evans), 87
cultural impacts in history, 22–41
limited application, 22
culture shock, 15, 26, 28; in history, 22, 41; surviving, 35, 38–41
cybernetics, 65
Cyclops radio telescope, 83, 90

databanks, 76–8
developmental history, *see* evolution
Dickson, Gordon R., 21
dolphins, *see* cetaceans
Drake, Frank, 73, 82
Dyson, Freeman, 83

encounter 'equation', 21, 22, 42, 47
ETI, 123–40; attitudes towards, 14, 19–21, 86–98; chemistries, 123–6
ETI 'civilisations', 27, 46–7, 49–50, 51, 79–80, 83, 87, 98, 101, 103, 108, 131–2
ETI encounter:
attitudes towards, 14, 16, 86–98
historical analogies, 22–41
manipulated, 51–9
possible reactions to, 31, 32, 51–9, 80–1, 86–98, 114–15, 121, 147–151
preparation for, 17–21
types, 145–6
ETI evolution, 41, 44–8, 106, 127
ETI in fiction, 15, 21, 54, 77, 123–5, 135, 146–7, 151, 152–3
ETI technology, 31–2, 95–6, 99–111, 148–9
Epsilon Bootis, 86–92
espionage, *see* security agencies
eugenics, 65–6

Europeanisation, *see* Westernisation
Evans, Christopher, 87
evolution, 42–50; cultural, 62–71; of brains, 46, 61; of ETI, 42–4, 106, 127
extrasensory perception, 61, 113, 128–30, 150–1

Fermi, Enrico, 131
France, 120
future, 62–71, 149, 166–9

Galactic Club, 132, 136–8
galactic society, 24, 39, 53, 131–41
genetic engineering, 65–6, 136–7
Gold, Thomas, 124

Herodianism, 22–3, 26, 31, 32, 35
heterogenous societies, 39, 41, 133–140
Hewish, Anthony, 82
Hoyle, Fred, 124
hybrids, man/machine, 67–71
Hyneck, J. Allen, 112

Inca, 23, 26, 27
India, 40
Intelligent Life in the Universe (Sagan and Shklovski), 95
interstellar flight, 53, 78–80, 88–91, 154–65
interstellar probes, *see under* CETI

Japan, 27–31, 32
Jung, Carl G., 55, 87, 114
Jupiter, 29, 59

Kardashev, Nicolai, 81, 83
Koestler, Arthur, 17
Kopal Zdenek, 89
Kornbluth, Cyril, 64

LGM, 82
Lamarckism, 43
Lawton, Anthony, 87
long-delayed echoes, 87, 109–11
Lovell, Sir Bernard, 72, 73–4
Lunan, Duncan, 86–98

M13, 84
McLuhan, Marshall, 38
machine intelligence, 67, 71, 137–8
Man and the Stars (Lunan), 86, 88 97
mathematics and ETI, 47, 127
Maya, 23, 26
Morrison, Philip, 72, 80, 84
Mote in God's Eye, The (Niven and Pournelle), 63–4
Mughal empire, 40

NASA, 15, 149
NATO, 150
Nineteen Eighty-four (Orwell), 64
Niven, Larry, 63–4

Orwell, George, 64
oysters, 44–7
Ozma project, 73–4, 82

Pacific native populations, 23
past contact, *see under* CETI
Perry, Admiral M. C., 29
Phobos, 81
Pizzaro, Francisco, 27
Pohl, Fred, 64
Pournelle, Jerry, 63–4
psychology, *see* behaviour
pulsars, 81–3
Purcell, Edward M., 90, 91

'Q' waves, 80

radar pulse, 100–1
radio and TV communication, 25
radio searches, *see under* CETI
Reign of George VI, The (anon), 64
Relativity, Theory of, 154–62
Royce, Joseph, 127

SETI, *see* CETI
Sagan, Carl, 19, 88, 92, 96, 124, 133
Samurai, 28–9, 31
science fiction, 14, 19–21, 39, 63–4, 104, 123–5, 142–4, 146–7, 151, 152–3, 154
security agencies, 67, 69, 115–17, 149
Shklovski, Josef, 81
significance, *see* thought processes
Solar System's origins, 144
Solaris, 123, 124, 135, 153
Space-Gods Revealed, The (Story), 75, 92
spaceprobes, extraterrestrial, *see under* CETI
Spanish invasion of America, 23, 26
Spock, Mr, 55
Sputnik 1, 148
Star Trek, 15, 54
Star Wars, 123, 153
Story, Ronald, 75, 92
Strong, James, 87
Study of History, A (Toynbee), 22
superspace, 154

Teilhard de Chardin, 60
thought processes, 16, 17, 43, 46–50, 51–9, 99, 127–30, 136–7, 139–40
Toffler, Alvin, 15
Toynbee, Arnold, 22, 148
Tribbles, 55–6
2001: A Space Odyssey, 77, 123, 153

UFOs, 55, 72, 74–5, 112–22, 130
United States, 28

vN, 101–11, 139–40, 144, 145
Velikovsky, Immanuel, 93
Viking Mars lander, 121, 126
von Däniken, Erich, 75–6, 92–4
von Neumann, John, 101

War of the Worlds, The (Wells), 15, 19, 21, 88, 115, 146, 151, 152
Warsaw Pact, 150
Welles, Orson, 15, 88, 115
Wells, H. G., 19, 20–1, 146, 151
Westernisation, 23–4, 25–30, 34–8, 39, 41
whales, *see* cetaceans
Wheeler, John, 154
White, James, 124
Wiener, Norbert, 65

Zealotism, 22, 28–31, 32, 35, 41, 148
zoo hypothesis, 132, 137, 148

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